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DANCING DIAMONDS IN HIGHWAY WORK ZONES: AN EVALUATION OF ARROW-PANEL CAUTION DISPLAYS

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UDOT RESEARCH & DEVELOPMENT REPORT ABSTRACT

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16. Abstract Nondirectional arrow-panel displays are used on highway work projects as an early warning caution sign. This report compares the non-standard "Dancing Diamonds" and "Flashing Diamonds" with the standard "Flashing Box" display. Field research shows that "Dancing Diamonds" is associated with cautious driving, whereas the "Flashing Box" has no association. Comprehension survey questions show little difference in comprehension between the three different signs. Opinion survey questions show that motorists strongly consider either diamond display better than the "Flashing Box" at prompting safe driving near highway work.			
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1. INTRODUCTION

Arrow panels have been widely used in highway work zones for the past twenty-five years. These panels are signs, consisting of a matrix of lights, that convey additional warning and direction symbolically to motorists. This matrix of lights is capable of flashing directional displays as well as nondirectional displays. Directional displays, such as "Flashing Arrow" and "Sequential Chevron," have been effectively used to aid drivers in switching lanes. This is the main purpose of arrow panels and the main reason to invest in this type of equipment. However, to maximize safety per dollar of investment, a nondirectional "caution" display has also been used. This caution display is the only nondirectional arrow panel display authorized by the current Manual on Uniform Traffic Control Devices (MUTCD) and is designated "Flashing Caution" (*1*).

The purpose of the caution display is to increase safety near highway work. Caution displays provide additional warning to drivers, so that they may exercise caution when approaching and traveling through a work zone. Safely slowing down, switching lanes on a multilane highway, or being more alert are all acceptable forms of "exercising caution." The caution display is currently designated for shoulder work operations and lane closures on a two-lane, two-way highway (*1*). Unlike all other arrow panel displays, the caution mode never requires the driver to make a lane change. Even when used at a temporarily closed lane of a two-lane, two-way highway, the caution display is meant only to alert the driver and to call attention to the other traffic-control devices.

Figure 1 shows five patterns proposed as caution displays in the past twenty-five years:

- **"Flashing Box" or "Flashing Four-Corner"**: Four lights, arranged as a box, simultaneously flash on and off (currently allowed in MUTCD 2000).

- **"Dancing Diamonds" or "Alternating Diamonds"**: Two diamonds, composed of sixteen lights, alternately flash back and forth (allowed only before MUTCD 2000).

- **"Flashing Diamonds"**: Two diamonds, composed of sixteen lights, simultaneously flash on and off (allowed only before MUTCD 2000).

- **"Bar" or "Flashing Line"**: Four lights, arranged as a line, simultaneously flash on and off (currently allowed in MUTCD 2000).

- **"Alternating Two-Corner"**: Two lights, for a total of four lights, alternately flash back and forth (allowed only before MUTCD 2000).

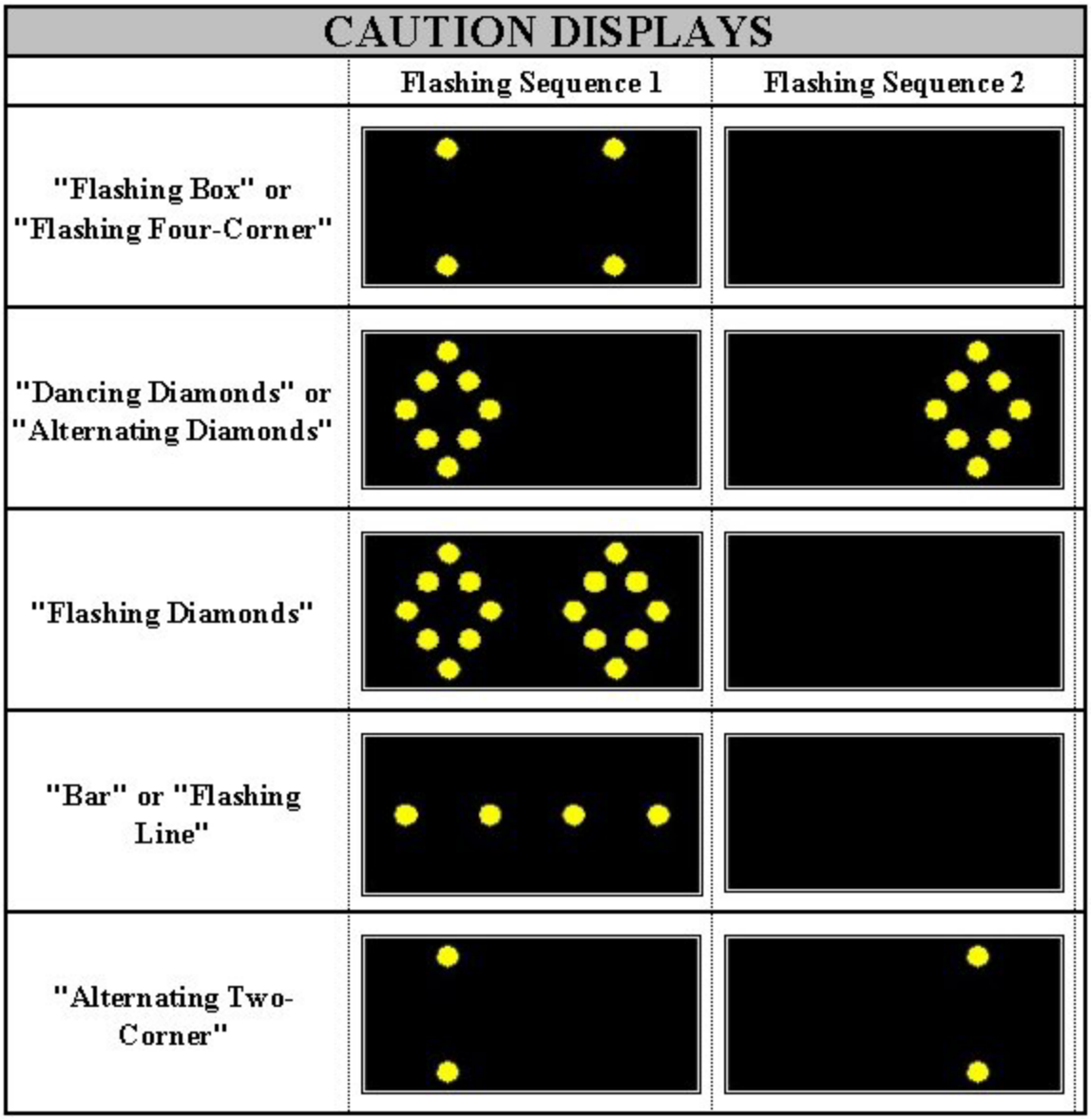

Figure 1 – Various Forms of Caution Displays

Before the MUTCD 2000 edition, the Flashing Box and Bar were suggested, but any "caution mode consist[ing] of four or more lamps" which "did not indicate a direction" was permitted (*2*). The Flashing Box and Bar have been used throughout the United States. The Dancing Diamonds pattern has been used in the western States, such as Utah and Oregon. The Alternating Two-Corner display has been studied in the past but to the author's knowledge has not been used. The Flashing Diamonds was proposed recently by the Utah Department of Transportation (UDOT) for additional study in this study.

The main purpose of this research is to evaluate the effectiveness of the Dancing Diamonds caution display as compared with the standard Flashing Box caution display. At UDOT's request, consideration for the Flashing Diamonds was added midway through this research and, consequently, is analyzed in the comprehension/opinion surveys only.

Chapter 2 further explains the scope of research. Chapter 3 outlines the methodology used in this study. Chapter 4 gives a detailed account of past research concerning caution displays. Chapter 5 outlines the design for the field tests and opinion surveys. Chapters 6 and 7 present the findings from both the field test and opinion survey. Chapter 8 provides these conclusions:

- The Dancing Diamond display is associated with cautious driving, whereas the Flashing Box display seems to have little effect on drivers, and

- There was little difference in driver comprehension between the Dancing Diamonds, Flashing Diamonds, and Flashing Box displays. However, a majority of respondents felt that the Dancing Diamonds display best prompted safety near highway work.

Recommendations are set forth in Chapter 9. References and Appendices are also provided.

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2. SCOPE OF RESEARCH

The ultimate goal of this research is to increase safety for drivers and roadway workers. Roadway workers use existing arrow boards for additional advance warning to drivers, promoting highway safety. Which caution display pattern best promotes safety for both drivers and highway workers? The goal of the research was to evaluate the relative effectiveness of Dancing Diamonds and Flashing Box caution displays. The Flashing Diamonds caution display is also studied. The empirical conclusions of this research will aid policy-makers in using the safest roadway devices.

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3. METHODOLOGY

Three areas of research are studied in this study. First, past caution display research was reviewed. Second, a randomized field experiment was conducted that compared the Dancing Diamonds and the Flashing Box caution displays. Third, comprehension/opinion surveys were carried out that compared the Dancing Diamonds, Flashing Box, and Flashing Diamonds (added midway through the research at UDOT's request) caution displays.

Past Research

Past research provides a foundation for current caution display practices. Two questions are considered. First, what scientific evidence are the current standards based on? Second, which display type does past research suggest is the most effective at promoting safety?

Field Experiment

This randomized field experiment measures the reactions (response) of the actual driving public (test subject) to two different caution displays (stimuli)—Dancing Diamonds and Flashing Box. The field test is replicated numerous times at different locations. Other factors, such as urban vs. rural locations and daytime vs. nighttime conditions, were also considered. Our measures of effectiveness were:

- *Speed reduction*. Which display is better at cautiously reducing vehicular speeds?
- *Lane migration*. Which display causes lane migration? Safe for multi-lane, urban facilities; unsafe for single-lane, rural facilities.
- *Conflicts*. Which display causes obvious unsafe conflicts?

Ideally, this randomized experiment should establish statistically sound relationships between the public driving responses and the two caution displays.

Comprehension/Opinion Surveys

Considering three types of caution displays—Dancing Diamonds, Flashing Diamonds, and Flashing Box—these surveys answer the following questions:

- What do drivers think the caution displays mean?
- Which caution display do drivers think best prompts safe driving?

Ideally, this randomized survey should establish how the general driving population interprets caution displays. Also, this survey should indicate driver preferences for various displays.

4. LITERATURE REVIEW

Caution nondirectional displays have not been studied exclusively until recently. This review will first focus on past research, which is the foundation for current standards. In this past research, caution displays are appendages to broader research on directional displays. Consequently, only the caution display segments of these reports will be examined. Second, this review will look at recent Oregon Department of Transportation (ODOT) research (*2*), which focuses specifically on caution displays. With scientific evidence, ODOT's research suggests that some caution display types are more effective than others.

Past Research

Of the past research, a December 1978 Federal Highway Administration (FHWA) report is discussed first (*3*). This 1978 report consists of two separate studies: a human factor study and a field study. Each study is accompanied by a set of recommendations. Next, a FHWA report from 1989 is discussed that outlines the then-current use of caution displays.

Human Factors Study. The authors of this study, Knapp et al., also published these findings separately in the Transportation Research Record (*4*). The authors explained that they created a series of film clips of different arrow display types (directional and nondirectional). This film was shown to twenty respondents (research company employees) as the respondents answered multiple choice questions.

From the results of the survey, Knapp et al. suggested that nondirectional displays, or mere blinking lights, "stirred more confusion than they aroused meaning" (*4*). However, speaking of the survey the authors confessed that their "film efforts, sample size, and composition were limited and unrefined." Thus they recommended a much more detailed investigation of nondirectional arrow-board displays.

Field Study. Graham et al., the principal authors of the 1978 FHWA report, conducted extensive arrow panel field research using actual work zones. However, only five maintenance shoulder closures were relevant to this discussion. One work zone used the Bar type of caution display. Two work zones had "Flashing Arrow" (directional) displays. The other two zones had no arrow-panel displays.

Research data were collected for one hour or less at each test location. A researcher stood in the back of the maintenance trucks and filmed oncoming traffic. The equipment used was a 16 mm camera with time-lapse photography. Based on these testing techniques, Graham et al. concluded that "slow-vehicle conflicts [when a vehicle swerves or brakes to avoid a slower vehicle in front] are increased when the [Bar display] is used" (*3*).

In Appendix B of the 1978 FHWA report, Graham et al. offer guidelines for arrow-board use. Using the results from both the human factor study and their field study, they recommend the following: "All other arrow board modes such as…non-directional displays should not be used for construction and maintenance activities."

Summary of 1989 Caution Display Practices. A 1989 FHWA report was written as both a review of past research and a survey of then-current practices. After looking at much the same literature mentioned previously, Noel et al. concluded that "Drivers' understanding of the arrow panel display for shoulder work…is not yet documented convincingly and should be researched further" (*5*).

In their survey of current practices, they spoke with highway officials in California, Illinois, Maryland, Michigan, New York, Virginia, and Pennsylvania. From these discussions they found that the Flashing Box and Bar displays were used. However, Noel et al. commented:

> There is a concern on the part of some researchers and highway agencies that the [Bar display] may be interpreted by drivers as a malfunctioning flashing arrow resulting in unnecessary lane changes. Consequently, some agencies prefer the [Flashing Box display] for caution displays.

Noel et al. concluded, "The [Flashing Box display] appears to be the preferred choice in most states" (*5*).

ODOT Caution Display Research

The research conducted by ODOT parallels this 2002 study. It also has a caution mode history, a field study, and a driver comprehension/opinion survey. Additionally, ODOT conducted a survey of other state Departments of Transportation (DOT).

History of Caution Displays. In their introduction, Griffith and Lynde clearly explain the history between the MUTCD and specific caution displays. Although both the Flashing Box and the Bar were suggested prior to the MUTCD 2000, any caution mode was allowed as long as it consisted "of four or more lamps, arranged in a pattern which will not indicate a direction" (*2*). However, the first edition of MUTCD 2000 specified the Flashing Box as the only caution display. Griffith et al. commented that the Bar was inadvertently omitted in the MUTCD 2000 and that that omission will be corrected in future revisions. Indeed, the current MUTCD 2000 edition allows both Flashing Box and Bar displays. Due to these specifications, ODOT discontinued use of its traditional, and favored Dancing Diamonds caution display.

Survey of State DOTs. This survey complemented the Noel et al. 1989 research discussed above. Most of the states that responded used the Flashing Box or Bar displays. A small minority of states had used the Dancing Diamonds display.

Field Tests. ODOT's research tested two highway temporary work-zone locations for one day each. At both locations, the Flashing Box, Bar, and Dancing Diamonds were used at various hours during the test. The researchers concluded, based on lane distributions and speed information, that "the [Dancing Diamonds] display performed as well [as], if not better than, the [Bar] or [Flashing Box] displays" (*2*).

Comprehension/Opinion Survey. ODOT surveyed 274 drivers at highway rest areas. Three arrow board trucks were set up to show the Flashing Box, Bar, and Dancing Diamonds for the survey. The majority of drivers (61%) found one or more of the signs confusing. However, 75% chose Dancing Diamonds as the "most effective at getting their attention." Eighty percent preferred the Dancing Diamonds for use on Oregon highways.

Summary of Past Research

First, due to a lack of comprehensive research, current MUTCD caution display standards are based on professional opinions and past experience. Notwithstanding, the research conducted in 1979 concluded that nondirectional displays are confusing and should not be used at all.

Second, recent field research by ODOT shows that the Dancing Diamonds caution display performed as well as, if not better than, MUTCD standard displays. Furthermore, comprehension/opinion surveys show that although drivers find the caution displays confusing, a vast majority (80%) prefer the use of the Dancing Diamonds over the Flashing Box or Bar displays.

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5. DESIGN OF EXPERIMENTS

Two statistical methods of analysis are used to determine which caution display patterns were most effective. First, a randomized field experiment was conducted to measure the reactions (response) of the driving public (test subject) to two different caution displays (stimuli). Second, an opinion survey was given to measure driver knowledge of and preferences for caution displays.

Field Experiment Design

The goal of the field experiment was to collect quantifiable data that measured the effectiveness of the Dancing Diamonds and Flashing Box caution displays. Data chosen for collection were speed reduction, lane migration, and conflict characteristics. Using these criteria and MUTCD standards, a general urban (multi-lane) layout and general rural (single-lane) layout were created. Figures 2 and 3 show these two layouts, respectively. These layouts show a typical shoulder work zone where a truck-mounted caution display is used.

Speed reduction. This criterion measured which caution display caused a greater speed reduction, if any. To measure this, a pair of pneumatic tubes (*6*) was placed to record speeds at three locations (refer to Figures 2 and 3):

- A "Free Flow" location where speed should not yet be effected by temporary signs, arrow board, and the work zone.
- A "Sign 1" location where the driver has read "ROAD WORK AHEAD" and can legibly see the arrow board display in the distance.
- An "Arrow Board" location where the driver actually passes the arrow board and encounters "friction" with channelization barrels.

Lane migration. Actual traffic was examined for lane-migration characteristics. With the aid of the UDOT Traffic Operations Center, urban locations were videotaped using Closed Circuit Television (CCTV) cameras used for the Salt Lake City metro area Advance Traffic Management System (ATMS). After the sites were videotaped, the videos were examined to count the percentage of vehicles safely leaving the right lane. For urban (multi-lane) roadways, migration from the right lane to the adjacent lane is somewhat desirable. This creates additional buffer space between drivers and construction or maintenance workers.

For rural (single-lane) locations, an observer in a van logged any conflicts, including any unsafe lane migration. Obviously lane migration is very unsafe and undesirable for two-lane, two-way facilities.

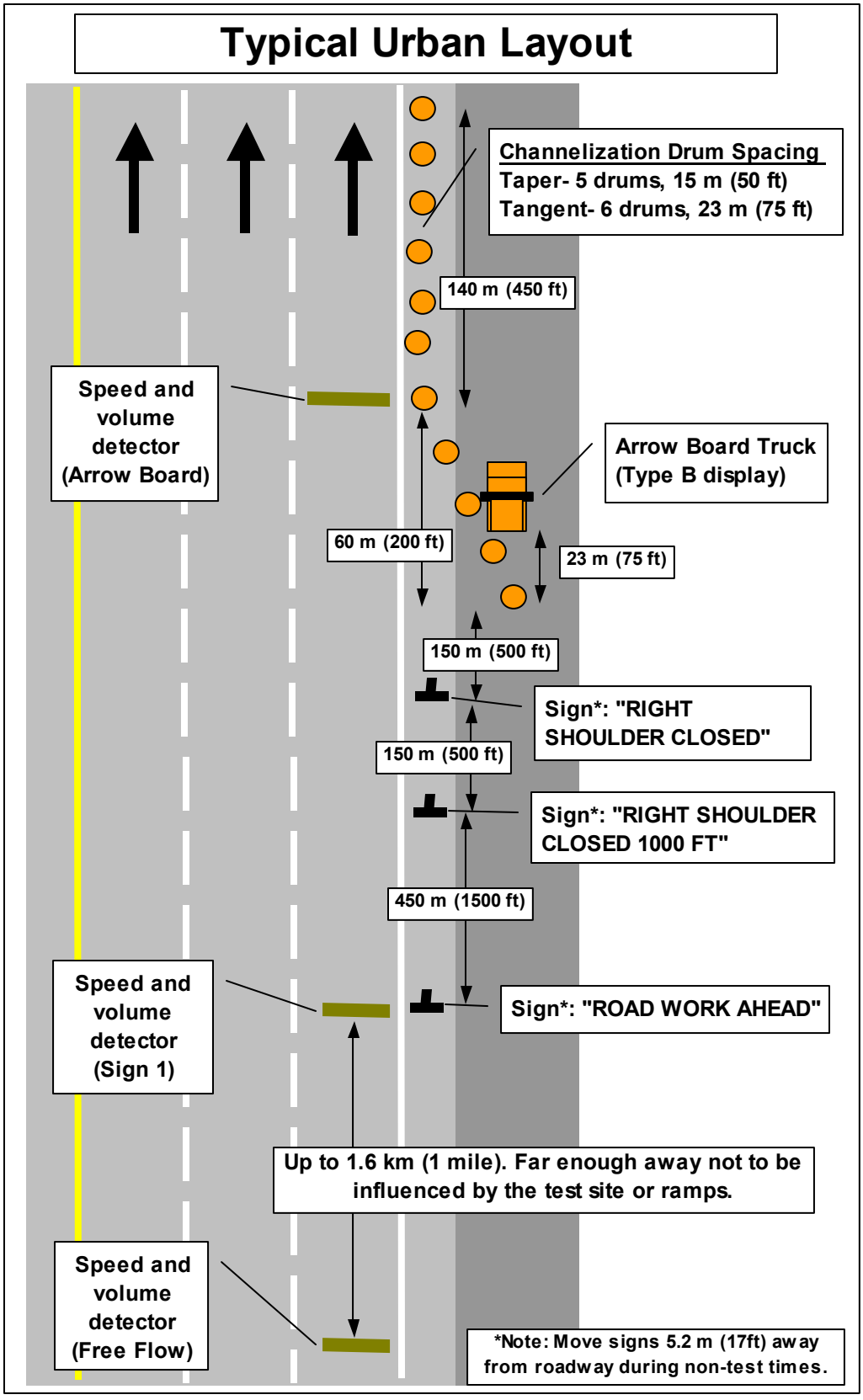

Figure 2 – Typical Urban (Multi-Lane) Field Experiment Layout

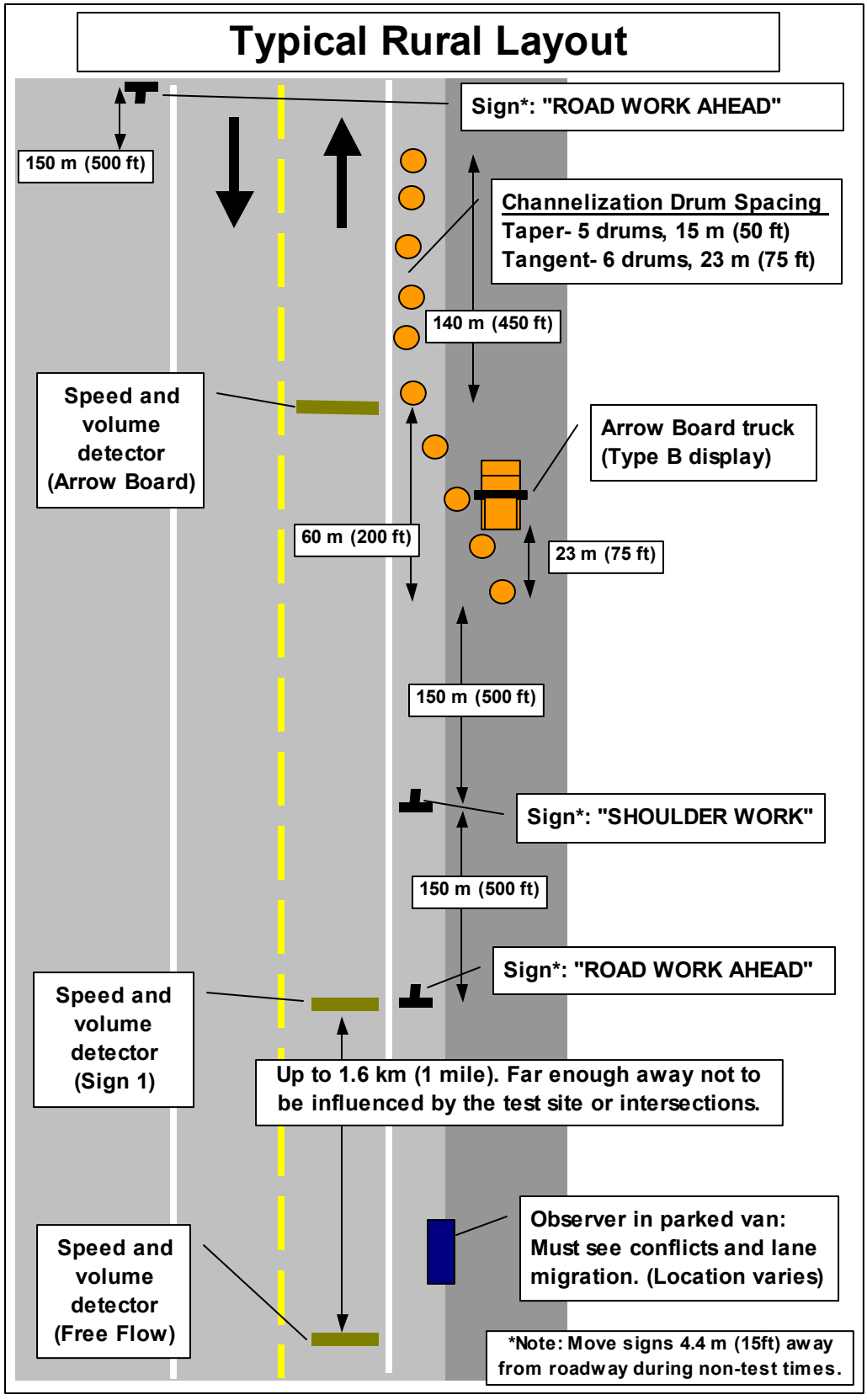

Figure 3 – Typical Rural (Single-Lane) Field Experiment Layout

Conflicts. Any unsafe vehicle conflicts were cataloged using the same visual recording techniques previously described. This cataloging was done by counting brake-lights (potential hard braking) and by subjectively tabulating any serious, recurring problems. It is important to identify potential conflicts, because a caution display could possibly distract or mislead motorists and result in unsafe maneuvers.

Test Locations. For statistical purposes, the test locations must be very similar and numerous. This necessitated using mock work zones located in "ideal" test locations. Ideal test locations were designated as straight general freeway segments, 1500 ft from any ramps or other access points, and situated such that a CCTV camera (for urban) or an observer (for rural) could visually see the work area. In all, 24 sites (12 urban, 12 rural) were selected.

Test locations were located in the Utah counties of Davis, Salt Lake, Utah, and Wasatch. Three urban test sites were along I-15 in southern Davis County. In Salt Lake County there were 9 urban test sites: two along I-15, five along I-215, one along I-80, and one along SR 201. Utah county had 8 rural test sites: two along US 89, four along US 6, and two along SR 92. Four rural test locations were also located along US 189 in Wasatch County (see Figures 4 and 5 for their general locations).

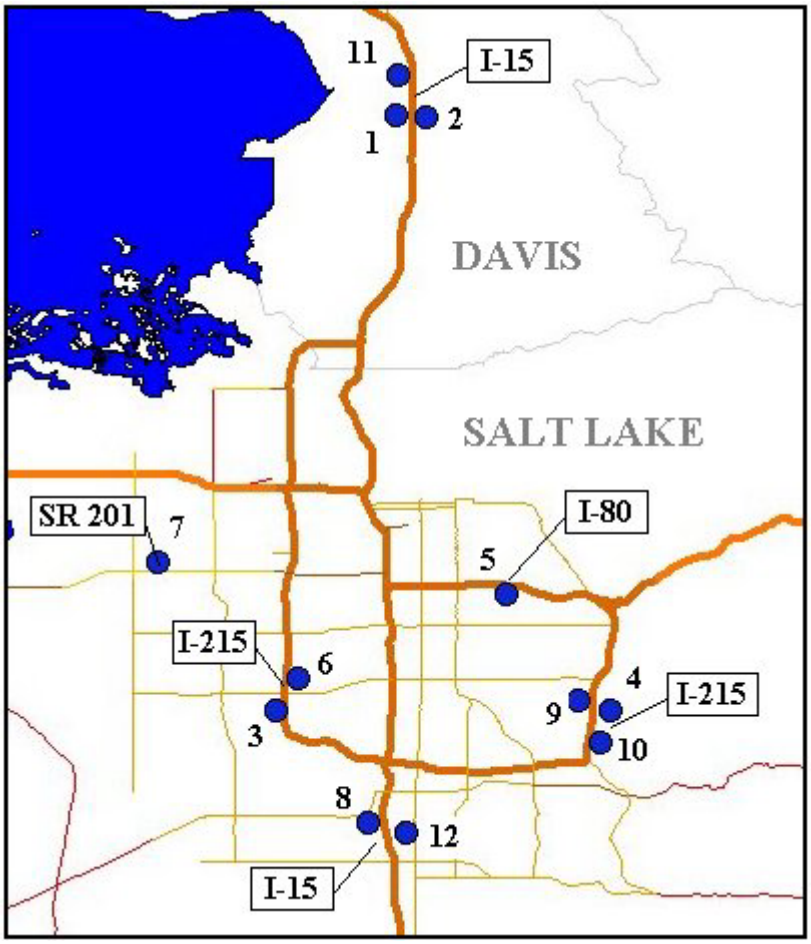

Figure 4 – Urban Test Locations

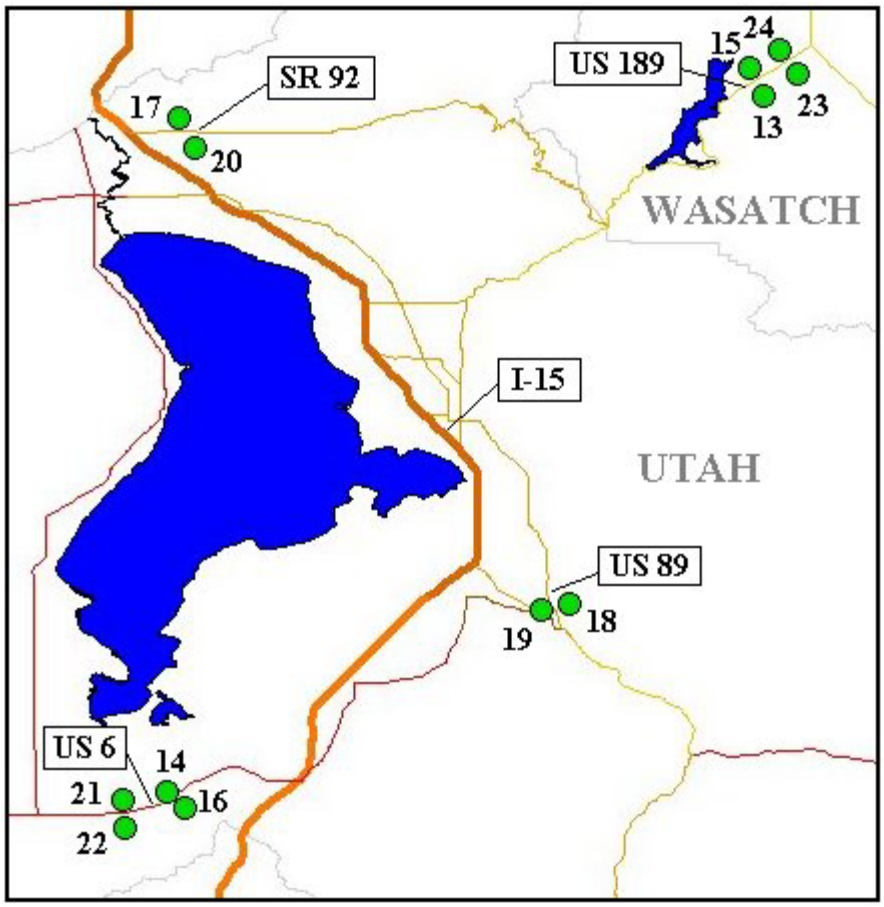

Figure 5 – Rural Test Locations

Test Timing. Each test site had two days of data collection: one day for the Dancing Diamonds display and one for the Flashing Box display. These two days of testing were scheduled at least a week apart. Only Tuesdays, Wednesdays, and Thursdays were used for stable weekday traffic. To ensure free flow conditions, tests were performed between 10:00 AM and 12:00 PM. To check display effectiveness in dark conditions, the tests were also performed at 3:00 AM to 5:00 AM for urban locations and 9:00 PM to 11:00 PM for rural locations.

Statistical Inference. The effect of a warning sign might wear off over time. Thus, half of the test sites had Flashing Box display the first week and Dancing Diamonds displayed the second week. Conversely, the other half of the test sites had Dancing Diamonds displayed first, then Flashing Box displayed. This order was assigned randomly for each location. Because of this random assignment and similarity between test sites, the researchers were able to determine if relationships existed between driver reactions and caution display type.

Form: AD FD FB .

THANK YOU!

Honestly mark the best answer (only ☑ ONE box).

1. In this situation, your *first reaction* would be to:

- ☐ Switch lanes if possible
- ☐ Slow down
- ☐ Pay more attention
- ☐ Continue normal driving
- ☐ Look for highway work

2. What does this sign mean *to you*?

- ☐ Shoulder work ahead
- ☐ Use caution ahead
- ☐ Proceed normally (Highway work has ceased for now)
- ☐ Lane closure ahead
- ☐ Do not know

3. In your opinion, which of these three signs would *best prompt safe driving* near highway work?

- ☐ Flashing Box
- ☐ Alternating Diamonds
- ☐ Flashing Diamonds

4. In your opinion, which of these three signs would *most likely be ignored*?

- ☐ Flashing Box
- ☐ Alternating Diamonds
- ☐ Flashing Diamonds
- ☐ None of them

5. Gender

- ☐ Male
- ☐ Female

6. How old are you?

- ☐ 16 to 19
- ☐ 20 to 29
- ☐ 30 to 39
- ☐ 40 to 49
- ☐ 50 to 59
- ☐ 60 to 69
- ☐ 70 +

7. How much time do you spend driving during a typical workday?

_____ hours _____ minutes

8. Which U.S. **state** have you done the most driving in?

_____ (State)

9. Which **county** have you done the most driving in?

_____ (County)

10. *Pick your candy bar and enjoy!*

Figure 6 – Comprehension/Opinion Survey Form

Comprehension/Opinion Survey Design

The goal of this comprehension/opinion survey was to collect quantifiable public opinions about the effectiveness of the Dancing Diamonds, Flashing Box, and Flashing Diamonds caution displays (refer to Figure 1 to see each display). The researchers wanted to know what drivers thought each caution display meant and which of the three displays they preferred. After one pilot survey, a one-page survey was finalized with nine multiple-choice and fill-in-the-blank questions. The actual survey is shown in Figure 6, and is explained below.

Comprehension Questions. Questions #1 and #2 consider what drivers thought a particular caution display meant. For these first two questions, each respondent only sees one of the three caution display types. Thus, approximately one-third of the total respondents will answer comprehension questions about each display.

Figure 7 – Sample Video Used For Survey Question #1

Figure 8 – Sample Video Used For Survey Question #2

Question #1. "In this situation, your first reaction would be to" is asked verbally while the respondent looks at a short video segment. The video shows a driver's perspective while driving down a highway (see Figure 7). A work zone with a caution display (Dancing Diamonds, Flashing Diamonds, or Flashing Box) appears on the right shoulder. The respondent then chooses one of the multiple-choice answers as his or her first reaction: "Switch lanes if possible," "Slow down," "Pay more attention," "Continue normal driving," or "Look for highway work."

Question #2. "What does this sign mean to you?" is also asked verbally while the respondent looks at another short video segment. This video is simply a close-up of the sign the respondent saw in Question #1 (see Figure 8). The respondent then chooses one of the multiple-choice answers as the meaning of the sign: "Shoulder work ahead," "Use caution ahead," "Proceed normally (Highway work has ceased for now)," "Lane closure ahead," or "Do not know."

Opinion Questions. Questions #3 and #4 gather opinions about each caution display. Each question is asked verbally while the respondent looks at all three caution display videos (collection of Question #2 videos) simultaneously.

Question #3. "In your opinion, which of these three signs would best prompt safe driving near highway work?" The respondent then chooses one of the multiple-choice answers: "Flashing Box," "Alternating Diamonds," or "Flashing Diamonds." (Note that the name "Alternating Diamonds" was used in this survey to avoid any "dancing" bias.)

Question #4. "In your opinion, which of these three signs would most likely be ignored?" The respondent then chooses one of the multiple-choice answers: "Flashing Box," "Alternating Diamonds," "Flashing Diamonds," or "None of them."

Demographic Questions. Questions #5, #6, #7, #8, and #9 gather characteristics of the driving population. This helps determine if different segments of the driver population have different perceptions or opinions about caution displays.

Question #5. "Gender" Multiple-choice.

Question #6. "How old are you?" Multiple-choice, generally bins of 10 years: "16-19," "20-29," "30-39," … "70 +."

Question #7. "How much time do you spend driving during a typical workday?" The respondent fills in the number of hours or minutes. This question identifies individuals who have more driving experience, thus more educated opinions.

Question #8. "Which U.S. state have you done the most driving in?" The respondent fills in the state name. This identifies individuals who have non-Utah driving experience.

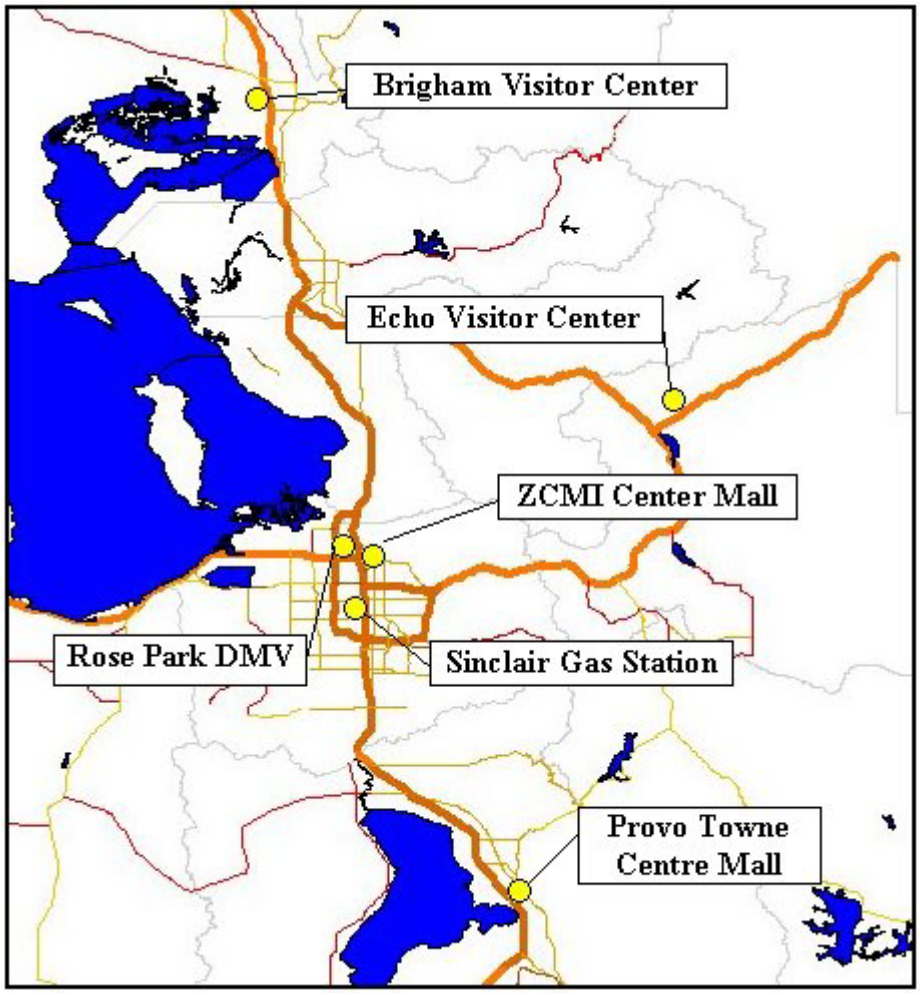

Figure 9 – Survey Locations

Question #9. "Which county have you done the most driving in?" The respondent fills in the county name. This identifies individuals who have urban or rural driving experience in Utah.

Survey Setup. A large 2 x 3-foot sign invites passers by to complete a driver survey for a free full-size candy bar. Candy bars are also displayed prominently between two laptop computers. Questions #1 through #4 are displayed using Microsoft PowerPoint software that allows the use of digital video files. Respondents sit and mark responses on survey forms as they watch one of two laptop computers. Once the survey is completed, the respondent chooses his or her favorite candy bar.

Survey Locations. Due to the self-selection nature of our survey, various locations with high volumes of driver populations (see Figure 9 for general locations) were chosen:

- *Utah Visitor Centers*. Echo Visitor Center located along WB I-80 near Utah/Wyoming border, and Brigham Visitor Center located along SB I-15 in northern Utah (UT).

- *Gas Station*. Sinclair/Burger King Gas Station located in Murray, UT.

- *Utah Department of Motor Vehicles (DMV).* Rose Park DMV located in Salt Lake City, UT.

- *Shopping Malls.* Provo Towne Centre Mall located in Provo, UT, and the ZCMI Center Mall in downtown Salt Lake City, UT.

Statistical Inference. Based on the large number of drivers surveyed and the varied survey locations, this survey approximates a random sample. Given this random sample, the results of this survey can be applied to the general driving population of the United States.

6. FINDINGS FROM THE FIELD EXPERIMENTS

Data were collected between July 17, 2001 and September 19, 2001. Figures 10 and 11 indicate where data are missing due to equipment, logistical, or human error. The speed reduction analysis is discussed first. The Dancing Diamonds display was found to lower mean speeds by approximately 2 mph, while the Flashing Box display showed no significant speed reduction. Lane migration analysis is discussed next, but there are insufficient data to make statistically significant conclusions. However, preliminary lane migration results show little difference between Dancing Diamonds and Flashing Box. Finally, conflict analysis is briefly discussed, because there was virtually no erratic movements or hard-braking affiliated with either display type.

Speed Reduction

The available speed data were compiled into an Excel spreadsheet data structure as shown in Table 1 (actual data are shown in Appendix A). Using SAS statistical analysis software (*8*), this speed data yielded a generalized linear model (GLM) using weighted least-squares. The model was weighted by the number of cars used to obtain the average speeds (see Appendix C). Average speed was the response variable. Explanatory variables, such as *Type* and *Time*, are shown in Table 1. A blocking variable (*Loc(Loctype)*) was also used to correctly analyze the *differences in* each site (i.e., between week 1 and week 2).

Through a process of insignificant variable elimination, the "full" GLM was simplified to a better fitting "reduced" GLM. Tables 2 and 3 show all the variables for the "full" GLM, whereas Table 3 shows only the variables for the "reduced" GLM. This reduced GLM had an R-squared value of 0.85, meaning it fit the speed data well. Using this reduced GLM, expected speeds for various situations were plotted. These plotted points were also analyzed to determine if there were statistical differences between them.

Insignificant Variable Elimination. A "full" GLM includes all the explanatory variables (*Type*, *Day*, etc.), blocking variable, and interaction terms (*Type*Where*, *LocType*Day*, etc.) thought to have an effect on the model. Through successive iterations, variables or terms were removed based on their significance value, called a p-value. If the p-value was above 0.10, then there was confidence that the variable was insignificant. Because of the more complex nature of interaction terms, a 0.20 cutoff was adopted for them. Table 2 outlines those variables that failed the standards set forth above and the order in which they were eliminated.(See notes about "blocking" and "interactions" at the end of this chapter.)

Final "Reduced" Model. Table 3 shows the variables and terms included in the final model. This final model had an R-squared term of 0.85, meaning that it fit the speed

Location	Type	Where	1	2	3	Location	Type	Where	1	2	3	Location	Type	Where	1	2	3
Site 1	Box (7/17)	FF				Site 5	Box (8/2)	FF			■	Site 9	DDmds (8/7)	FF			
		S1	■					S1			■			S1			
		AB						AB			■			AB			
	DDmds (7/24)	FF			■			FF	■	■	■		Box (8/14)	FF			■
		S1			■			S1	■	■	■			S1			■
		AB	■		■			AB	■	■	■			AB			■
Site 2	Box (7/18)	FF				Site 6	Box (7/31-8/1)	FF				Site 10	Box (8/8)	FF		■	
		S1						S1						S1		■	
		AB						AB						AB			
	DDmds (7/25)	FF			■		DDmds (8/7)	FF	■				DDmds (8/16)	FF			■
		S1			■			S1						S1			■
		AB			■			AB						AB			■
Site 3	DDmds (7/19)	FF				Site 7	Box (8/9)	FF			■	Site 11	Box (8/14)	FF	■	■	■
		S1						S1			■			S1	■		■
		AB	■					AB			■			AB	■	■	■
	Box (7/26)	FF					DDmds (8/23)	FF						FF	■	■	■
		S1						S1						S1	■	■	■
		AB	■	■				AB						AB	■	■	■
Site 4	(DDmds) (7/24)	FF	■		■	Site 8	Box (8/8)	FF				Site 12	DDmds (8/8)	FF			
		S1	■		■			S1						S1			
		AB	■		■			AB						AB			
	Box (7/31)	FF					DDmds (8/15)	FF			■		Box (8/22)	FF			
		S1						S1			■			S1			
		AB						AB			■			AB			

NOTE: 1 = Speeds (10am-12pm), 2 = Speeds (4am-5am), 3 = Visual
Color Code: WHITE = Data, BLACK = No data

Figure 10 – Urban Data Collection Summaries

Location	Type	Where	1	2	3	Location	Type	Where	1	2	3	Location	Type	Where	1	2	3
Site 13	Box (7/11)	FF				Site 17	Box (8/2)	FF				Site 21	Box (8/21)	FF	■	■	
		S1						S1						S1	■	■	
		AB						AB	■					AB			
	DDmds (7/17)	FF					DDmds (9/5)	FF		■			DDmds (8/29)	FF			
		S1						S1						S1		■	
		AB						AB						AB			
Site 14	DDmds (7/10)	FF	■	■		Site 18	DDmds (9/13)	FF				Site 22	Box (8/22)	FF	■		
		S1						S1						S1	■	■	
		AB	■	■				AB		■				AB			
	Box (7/18)	FF					Box (9/19)	FF					DDmds (8/30)	FF			
		S1						S1						S1	■	■	
		AB						AB		■				AB			
Site 15	DDmds (7/19)	FF				Site 19	DDmds (9/12)	FF				Site 23		FF	■	■	■
		S1						S1						S1	■	■	■
		AB						AB						AB	■	■	■
	Box (7/26)	FF					Box (9/18)	FF						FF	■	■	■
		S1						S1						S1	■	■	■
		AB						AB	■					AB	■	■	■
Site 16	Box (7/25)	FF	■	■		Site 20	DDmds (8/23)	FF				Site 24		FF	■	■	■
		S1	■	■				S1						S1	■	■	■
		AB						AB						AB	■	■	■
	DDmds (8/1)	FF					Box (8/28)	FF						FF	■	■	■
		S1	■	■				S1						S1	■	■	■
		AB						AB						AB	■	■	■

NOTE: 1 = Speeds (10am-12pm), 2 = Speeds (9pm-11pm), 3 = Visual
Color Code: WHITE = Data, BLACK = No data

Figure 11 – Rural Data Collection Summaries

Table 1 – Speed Data Structure

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
(FF, S1, or AB)	(Urban or Rural)	(1,2,…, or 22)	(1 or 2)	(Tue, Wed, or Thu)	(Day or Night)	(DD, BX)	# [mph]	# of Speeds Recorded

Table 2 – Table of Insignificant Variables

Order Removed	Variable	P-value	Meaning
1	*LocType*where1*	0.876	The effect of speed reduction is the same for both urban and rural locations.
2	*Order*Time*	0.757	The effect on average speeds for day and night is the same, whether it was the first or second week.
3	*LocType*Order*	0.599	The effect on average speeds between the first and second week is the same for both urban and rural locations.
4	*LocType*Time*	0.592	The effect on average speeds for day vs. night is the same for both urban and rural locations.
5	*LocType*Day*	0.386	The effect on average speeds for day of the week is the same for both urban and rural locations.
6	*Time*where1*	0.272	The effect of speed reduction is the same for both day and night times.
7	*Day*	0.153	The effect on average speeds for day of the week is insignificant.

data well. Note that the variable *Time* was still included, because it is involved with the significant interaction term *Time*Type*. The mathematical equation associated with this model is:

$$\begin{aligned}\textbf{Speed[mph]} = {} & 62.0 - (4.7 LocType_{\text{Rural}}) - (1.1 Order_1) + (1.2 Time_{\text{Day}}) \\ & + (3.7 Type_{\text{BX}}) + (1.8 Where_{\text{FF}}) + (1.4 Where_{\text{S1}}) - (1.9 LocType_{\text{Rural}} * Type_{\text{BX}}) \\ & + (1.6 Order_1 * Where_{\text{FF}}) - (1.0 Order_1 * Where_{\text{S1}}) - (1.2 Time_{\text{Day}} * Type_{\text{BX}}) \\ & + \mathbf{B}_{\text{Loc(LocType)}}\end{aligned}$$

where $\mathbf{B}_{\text{Loc(LocType)}}$ is the blocking variable linear function with 20 additional coefficients for each site. Please note that by using the blocking variable and weighted least-squares, ones and zeros cannot be simply inserted into this equation to obtain speeds. Expected

Table 3 – Table of Significant Variables (Final Model)

Variable	P-value	Meaning
LocType	< 0.001	Average urban speeds and average rural speeds are different.
Loc(LocType)	< 0.001	Blocking variable. Used to compare data differences within each test site.
Order	0.007	Average speeds during the first week are different than those during the second week.
Time	0.158	Needed for the interaction term *Time*Type* below.
Type	0.043	Average speeds for the Flashing Box display are different from those for the Dancing Diamonds display.
where1	0.007	The average speeds for the Free Flow, Sign 1, and Arrow Board locations are different.
*LocType*Type*	0.016	The effect of caution display is different for both urban and rural locations.
*Order*where1*	0.007	The effect of speed reduction is different between the first week speeds and the second week speeds.
*Type*where1*	0.003	The effect of speed reduction is different between Flashing Box and Dancing Diamonds displays.
*Time*Type*	0.164	The effect of day vs. night is different between Flashing Box and Dancing Diamonds displays.

speed values for these various conditions can only be calculated using statistical software. Appendix C contains a more thorough statistical data reduction discussion.

Using SAS statistical software, expected mean speed values were obtained and plotted for various circumstances. These plotted points were compared with each other using t-tests to obtain individual p-values that show any significant differences (i.e., p-values < 0.10).

Speed Reduction for Flashing Box vs. Dancing Diamonds. Figure 12 shows the plot of expected mean speeds from this GLM. The Flashing Box speeds have no statistically significant difference among themselves:

- Box (Free Flow) vs. Box (Sign 1) has a p-value of 0.99;
- Box (Sign 1) vs. Box (Arrow Board) has a p-value of 0.78;
- Box (Free Flow) vs. Box (Arrow Board) has a p-value of 0.75;

This shows that there is no statistically significant speed reduction associated with the Flashing Box caution display.

The Dancing Diamonds speeds, however, *do* show a statistically significant difference among themselves:

- Diamonds (Free Flow) vs. Diamonds (Sign 1) has a p-value of 0.01;
- Diamonds (Sign 1) vs. Diamonds (Arrow Board) has a p-value of 0.08;
- Diamonds (Free Flow) vs. Diamonds (Arrow Board) has a p-value of < 0.01;

This shows that there exists a statistically significant speed reduction associated with the Dancing Diamonds caution display.

This graph also yields statistical comparisons between the Flashing Box and Dancing Diamonds displays. The Free Flow speeds were not significantly different (p-value = 0.36). This validates our assumption that the Free Flow speeds should not have been affected by the caution displays. The Sign 1 and Arrow Board speeds were significantly different (p-value = 0.09 and < 0.01, respectively).

In conclusion, the Flashing Box caution display was not associated with any speed reduction, whereas the Dancing Diamonds caution display was associated with an approximate 2 mph speed reduction.

Other Comparisons. Figure 13 shows that the signs' effect on speed reduction diminishes over time. During the first week, speeds as a whole dropped more significantly than it did during the second week.

- Week 1 (Free Flow) vs. Week 1 (Arrow Board) has a p-value of < 0.01;
- Week 2 (Free Flow) vs. Week 2 (Arrow Board) has a p-value of 0.43;

Figure 14 shows that Dancing Diamonds are more effective at night. The Flashing Box display has the same effect whether it is day or night.

- Diamonds (Day) vs. Diamonds (Night) has a p-value of 0.05;
- Box (Day) vs. Box (Night) has a p-value of 0.98.

Finally, Figure 15 shows that overall rural speeds (not speed reductions) are about 8 to 10 mph less than urban speeds. Also, overall speeds for Dancing Diamond displays are lower than Box displays in urban locations (p-value < 0.01), but not in rural locations (p-value = 0.91).

Lane Migration

Lane migration was based on visual data collection. Unfortunately due to logistical problems, only three urban sites had video for both the Dancing Diamonds and

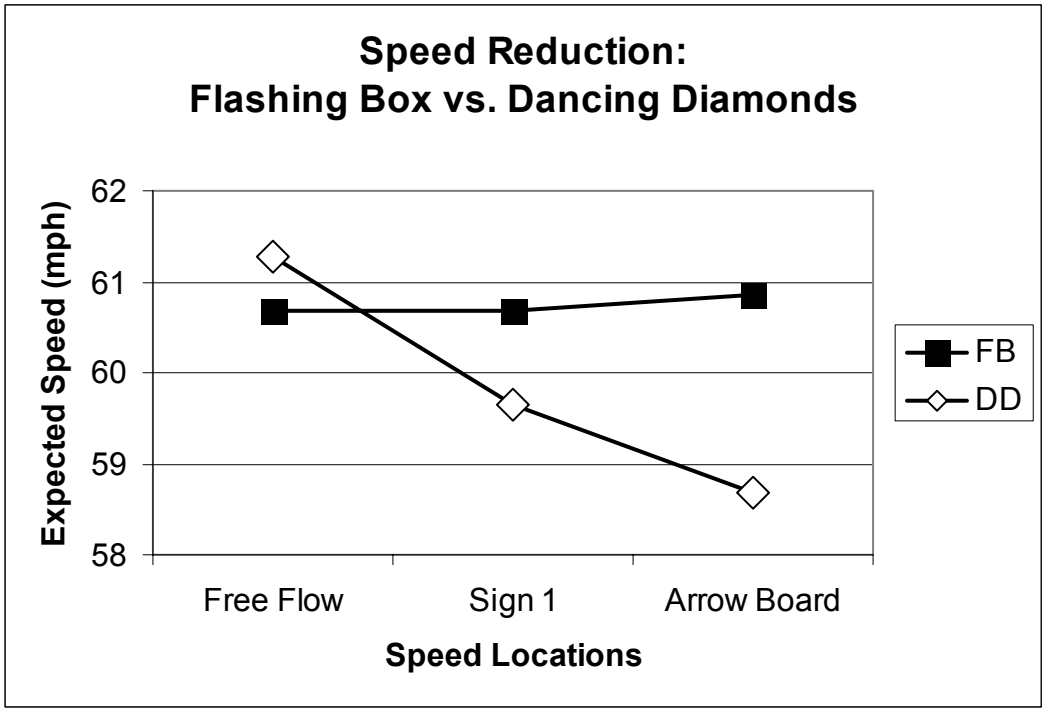

Figure 12 – Speed Reduction Plot

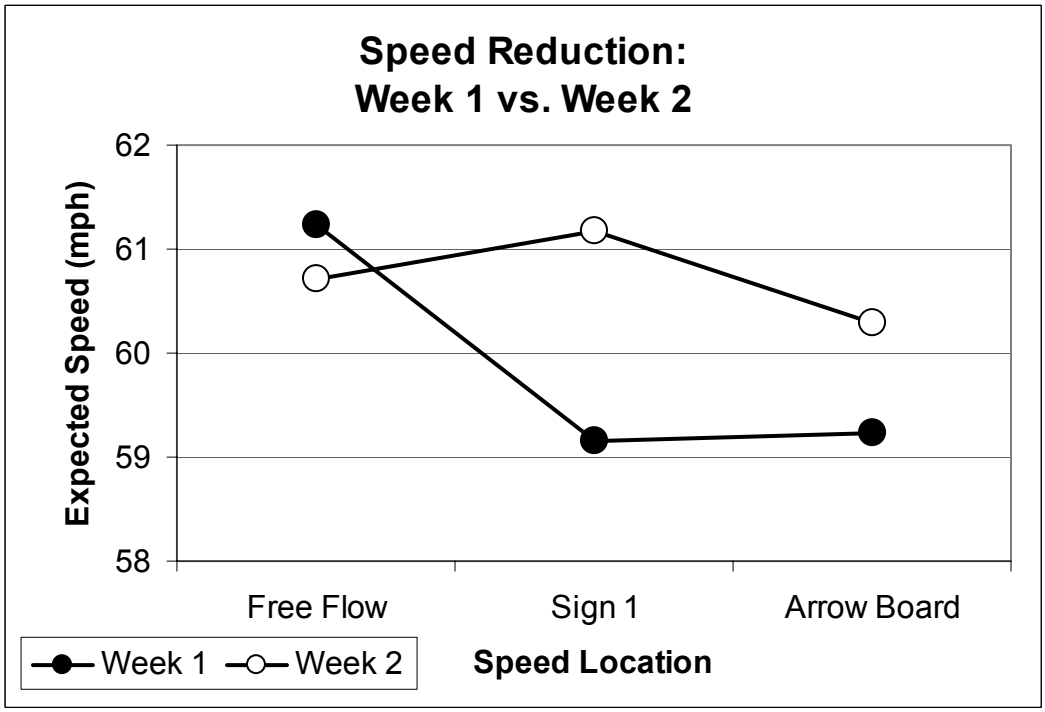

Figure 13 – Order Effects

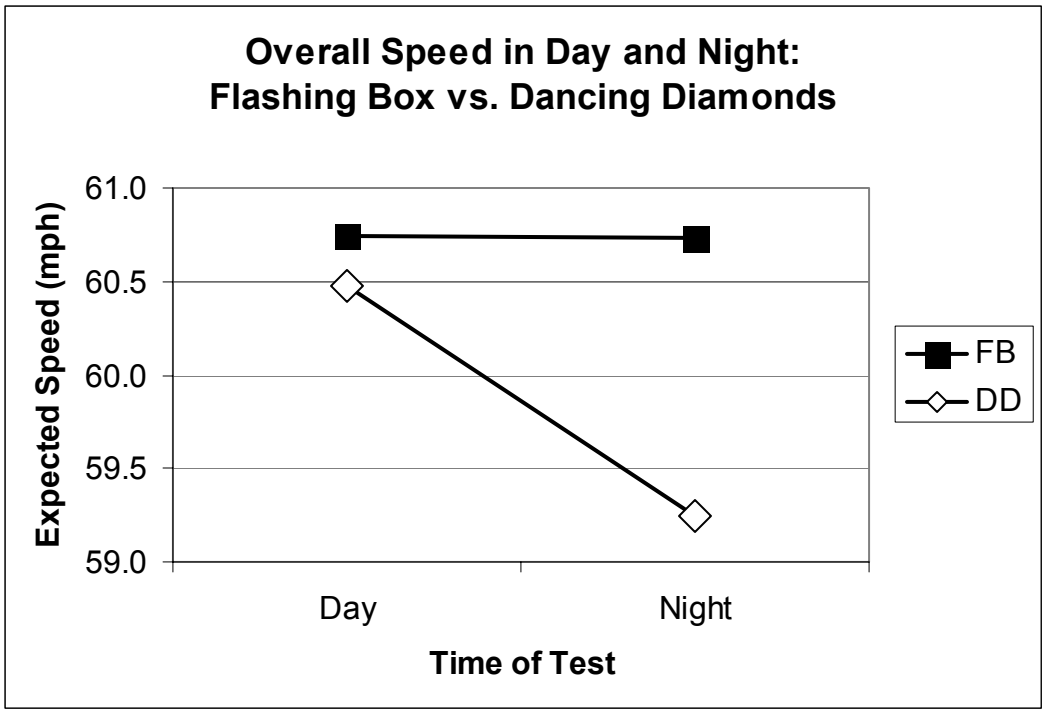

Figure 14 – Time Effects

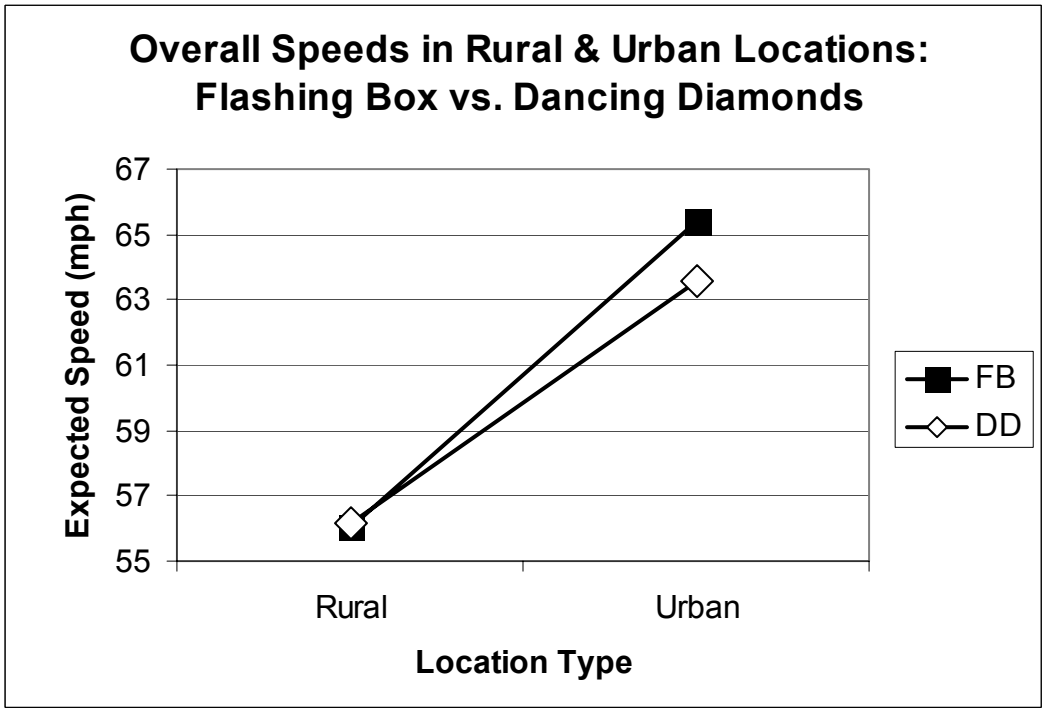

Figure 15 – Location Effects

the Flashing Box test periods (see Figure 10). No statistically significant results could be obtained, though preliminary analysis (using the little data collected) indicates no difference between the two caution displays. (See Appendix C for more details.)

For rural sites, lane migration was noticed only when there was no opposing traffic, and channelization barrels were near the travel lane. Lane migration behavior did not seem to differ based on the type of caution display. No unsafe lane migration was noticed.

Conflicts

Conflict analysis was a subjective measure of effectiveness used to notice any repeated unsafe driving in connection to the work zones. However, very little unsafe driving or hard-braking was noticed in connection with the work zone and caution displays.

Yet, in an effort for quantifiable analysis, any brake tapping was tabulated. Again there was insufficient data to make any statistically significant conclusions for urban data. Notwithstanding, preliminary analysis shows little difference between sign types. Rural data were sufficient and were analyzed using ANOVA. Even after taking into account time of day and the order in which sign types were shown, there was no significant difference in the number of people braking in both sign types (Dancing Diamonds vs. Flashing Box). The ANOVA table is shown in Appendix C.

Summary

The Dancing Diamonds caution display is associated with a minor 2 mph reduction in average vehicular speeds. The Flashing Box display is associated with no statistically significant reduction in speed. Lane migration seems to be similar and safe for both sign types. Neither caution display is associated with any obvious unsafe conflicts.

NOTES:

"Blocking" is a statistical tool to provide higher precision with large data sets. It grouped each test site so that the speed reduction at that test site would be analyzed. This is similar to the grouping needed for a paired *t*-test. Differences at each test site could be analyzed independent of differences between each test site.

"Interaction" variables are needed if the effect of one variable is thought to depend on the value of another variable. In statistics, interaction variables are shown as the product of two explanatory variables (e.g., *Type*Where*).

For a more detailed explanation on these terms see Reference 8.

7. FINDINGS FROM THE COMPREHENSION/OPINION SURVEY

A total of 412 surveys were administered at the locations and dates listed below in Table 4. There was little difference in driver comprehension between the Dancing Diamonds, Flashing Diamonds, and Flashing Box displays. A plurality of respondents (46%-55%) would "Slow down" upon seeing the caution display and a majority (55%-67%) think the signs mean "Use caution ahead." When asked which caution display best prompts safe driving, 54% chose Dancing Diamonds, 43% chose Flashing Diamonds, and only 3% chose Flashing Box.

Table 4 – Comprehension/Opinion Survey Locations

Date	***Location***	***Number of Surveys***
2 Jan 02	**Provo Towne Centre Mall** *Located in Provo, Utah as a regional shopping mall.*	115
12 Jan 02	**Echo Visitor Center** *Located along WB I-80 near Utah-Wyoming border.*	17
17 Jan 02	**Sinclair/ Burger King Gas Station** *Located in Murray, Utah.*	13
18 Jan 02	**Brigham Visitor Center** *Located along SB I-15 in northern Utah.*	10
19 Jan 02	**Sinclair/ Burger King Gas Station** *Located in Murray, Utah.*	13
21 Jan 02	**Echo Visitor Center** *Located along WB I-80 near Utah-Wyoming border.*	32
24 Jan 02	**ZCMI Center Mall** *Located in downtown Salt Lake City, Utah.*	147
25 Jan 02	**Rose Park DMV** *Located in Salt Lake City, Utah.*	44
26 Jan 02	**Echo Visitor Center** *Located along WB I-80 near Utah-Wyoming border.*	21
	Total Number of Survey =	**412**

Comprehension Questions

Each caution display (Dancing Diamonds, Flashing Diamonds, and Flashing Box) was shown in Questions #1 and #2 to one-third of the total respondents. (Please note that the name "Alternating Diamonds" was used in this survey to avoid any "dancing" bias.) Although respondents saw different caution displays, there was little difference in driver comprehension among the Dancing Diamonds, Flashing Diamonds, and Flashing Box displays.

Question #1 (See Figure 16). When asked what their first reaction would be upon seeing a particular caution display, drivers responded that they would slow down (46%-55%), switching lanes (26%-29%), paying more attention (10-15%), or looking for highway work (3%-5%). However, "Pay more attention" is technically the most correct answer. After applying a chi-square test to see if any response differed significantly between caution displays, only "Continue normal driving" did (p-value = 0.009). This means that Flashing Diamonds are significantly less likely to be ignored relative to the other displays. This may be related to the fact that Flashing Diamonds have never been used in practice, so some people have not "learned" to ignore it.

Question #2 (See Figure 17). After seeing a close-up view of the sign, the majority of respondents correctly identified a caution display's meaning: 55%-59% chose "Use caution ahead." Again a chi-square test was applied to see if any response differed significantly among caution displays. Only "Do not know" did (p-value = 0.026) with significantly more respondents being confused by the Flashing Box display.

Finally, quite a few respondents verbally commented that they thought the signs were malfunctioning. Others merely guessed that blinking lights mean caution.

Opinion Questions

Respondents were shown all three caution displays simultaneously, then they answered Questions #3 and #4.

Question #3 (See Figure 18). Question #3 asked, "In your opinion, which of these three signs would best prompt safe driving?" An overwhelming majority chose a diamond display (97%) over the Flashing Box display (3%). The Dancing Diamonds were favored most (54%) closely followed by the Flashing Diamonds (43%). Some respondents verbally commented that the side-to-side nature of the Dancing Diamonds "catches the eye" better than mere flashing. Others commented, "the more lights—the better," and chose the Flashing Diamonds.

Question #4 (See Figure 19). This question may be more accurately translated as "Which of these three signs is least effective at getting attention?" Nearly all the respondents chose the Flashing Box (94%). It should also be noted that a fourth option, "None of them," was also available and was a response only 4% of the time.

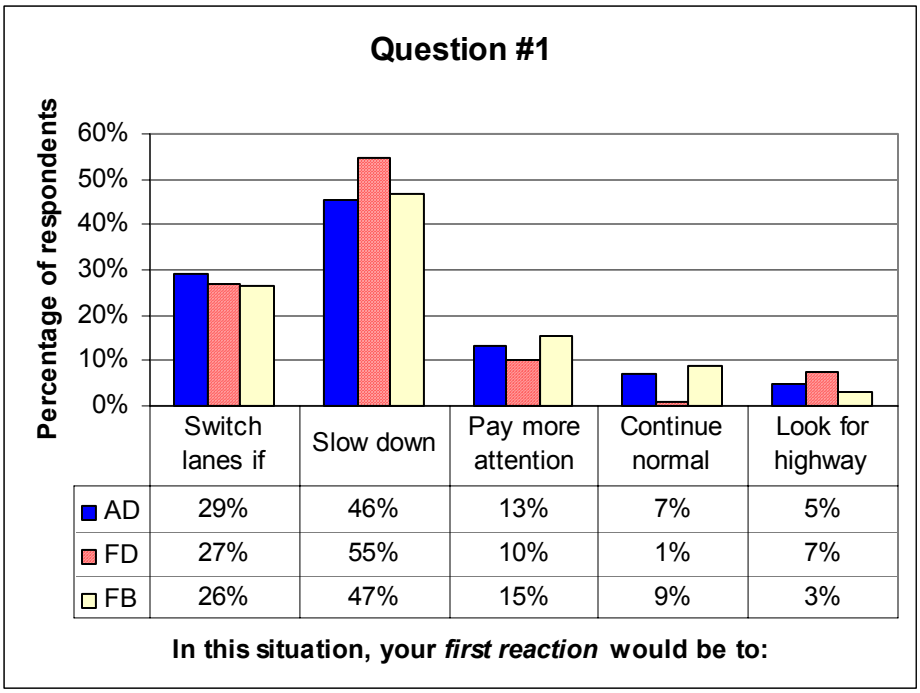

Figure 16- Question #1 Results

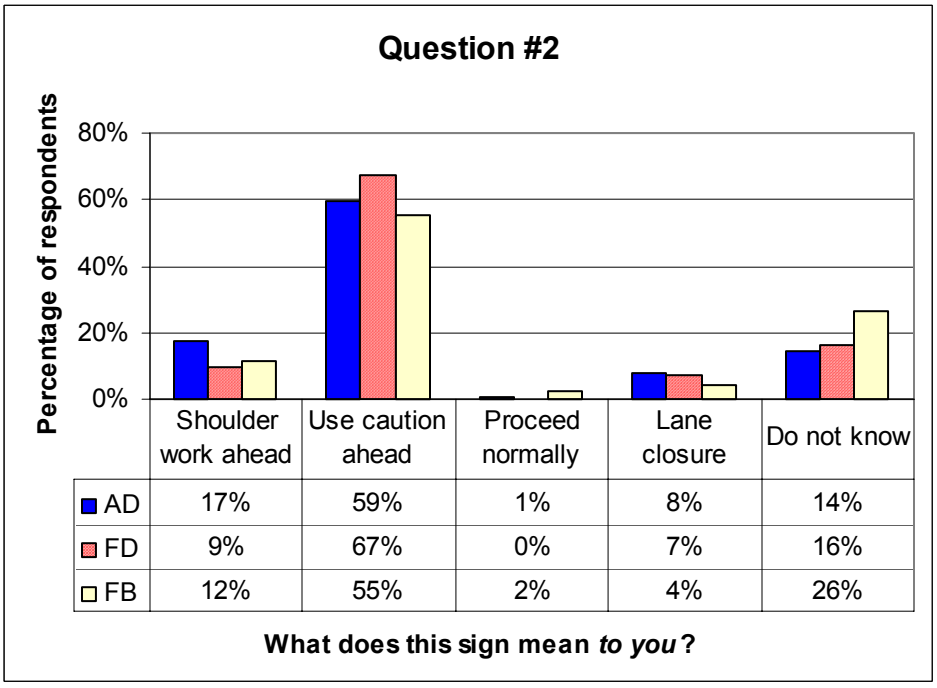

Figure 17- Question #2 Results

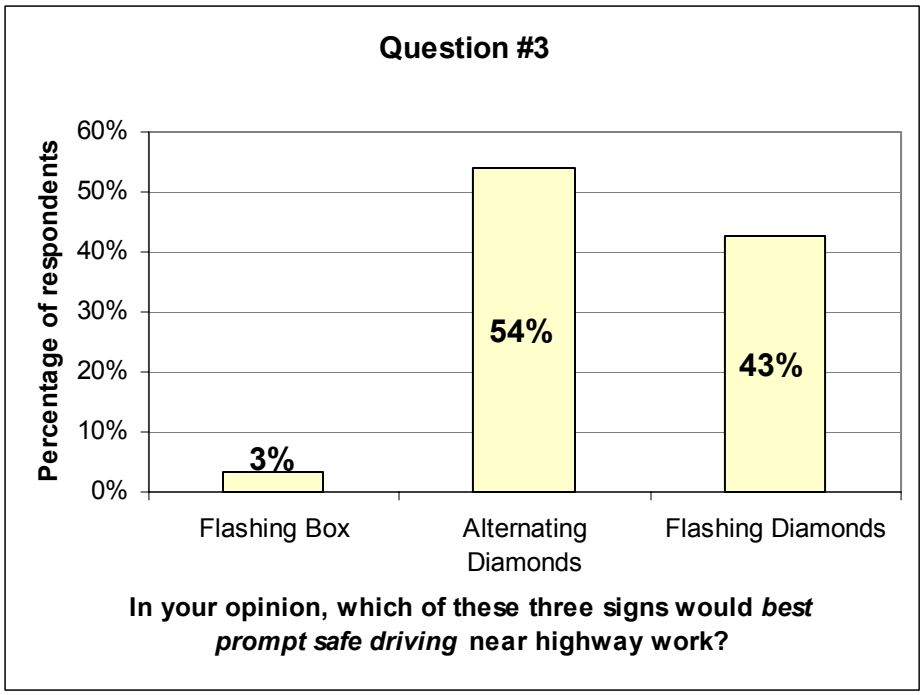

Figure 18 - Question #3 Results

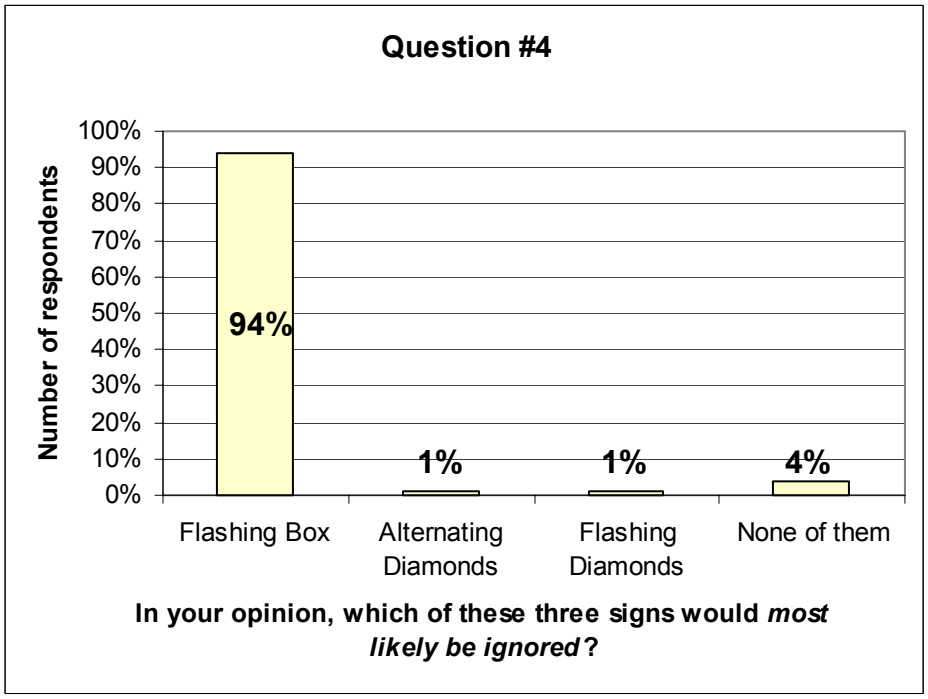

Figure 19 - Question #4 Results

Demographic Questions

The purpose of demographic questions are one, to see if a good cross section of the driving population has been surveyed, and two, to ascertain if any significant relationships exist between opinions and a segment of the driving population. These potential relationships are discussed in the next section.

Questions #5 and #6. Males account for 62% of the respondents, and females accounted for 38%. That, along with the age distribution shown in Figure 20, seems to be a reasonable sample of the driving population.

Question #7. The average time spent driving during a typical workday is 2.4 hours. However, the median time is only 1.5 hours. Several truck drivers driving 10+ hours skewed the average.

Questions #8 and #9. Obviously Utah was the most common state listed due to the location of the survey, but 28% of the respondents had more driving experience outside Utah (see Figure 21). This 28% represents 117 people from 24 states besides Utah. California drivers accounted for the plurality (34) of the 117 drivers (see Table 5). Question #9 (county information) was going to be used to determine urban vs. rural experience in Utah. However, it became apparent that urban vs. rural experience could not be determined simply by county, and was therefore not included in this analysis.

Statistical Relationships

To see the robustness of the answers given in Question #3 (Which display best prompts safe driving?), a chi-square tests was conducted between Question #3 answers and the following:

1. Which caution display the respondent saw in Question #1 and #2.

2. Those respondents who had more driving experience, or in other words, greater than the median 1.5 hours per workday.

3. Those with more driving experience outside Utah.

4. Gender.

The chi-square results show no difference in the answers for Question #3 and each the relationships listed above (p-values = 0.44, 0.90, 0.82, 0.38, respectively, for the above 4 factors). Therefore, respondents chose Dancing Diamonds regardless of survey bias, driving experience, or gender.

Some attention was given to the idea that drivers might confuse specific caution display types with directional displays. Respondents who chose “switching lanes” or

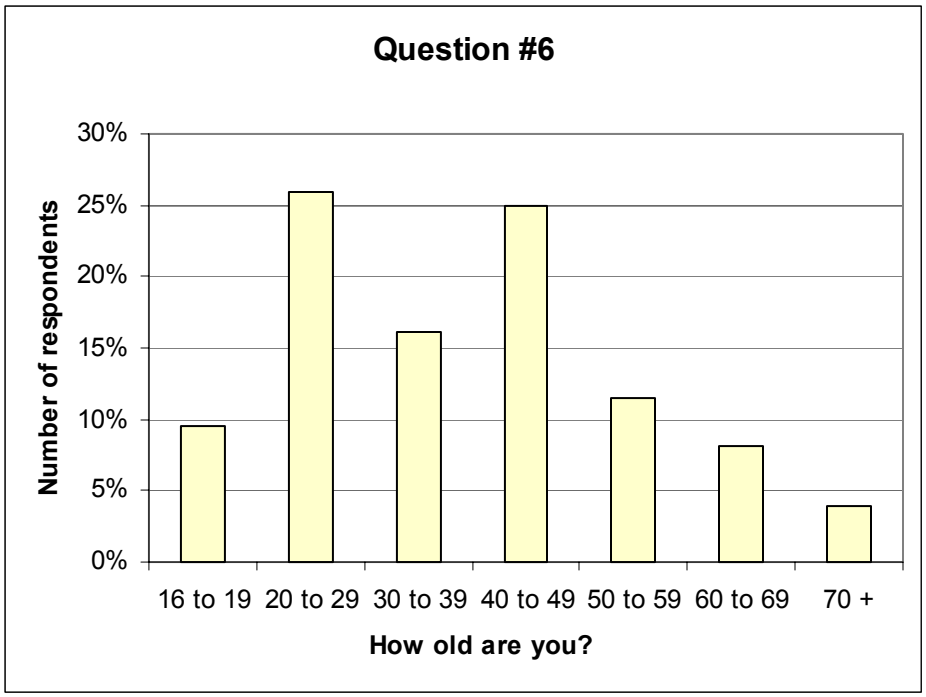

Figure 20 - Question #6 Results

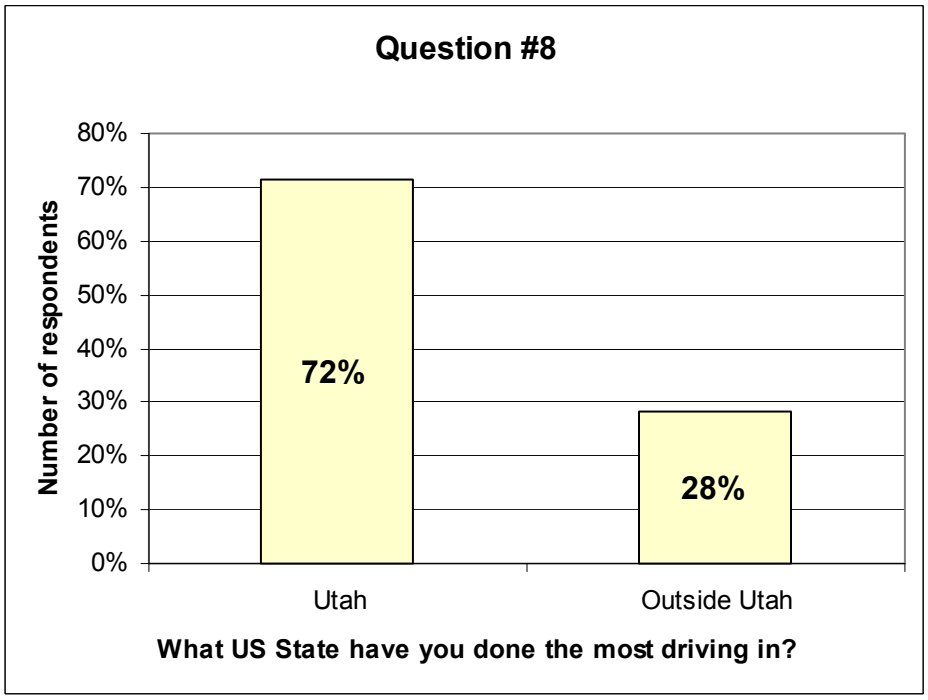

Figure 21 - Question #8 Results

Table 5 – Driving Experience Locations Listed in Question #8

Number of Responses per *Each* State	States (or Regions) Listed on Question #8
295	Utah
34	California
12	Wyoming, "Lower 48" (Truck drivers could not pick one state.)
8	Arizona, Idaho
6	Texas
5	"West" (Truck drivers could not pick one state.)
4	Colorado, Oregon
3	New York, Kentucky
2	Missouri, Tennessee
1	Connecticut, Florida, Hawaii, Iowa, Illinois, Massachusetts, Maine, Michigan, North Dakota, Pennsylvania, Virginia, Washington, Wisconsin

"lane closure ahead" may have thought the display was a directional display. Again chi-square tests were applied between the sign type seen in the first two questions and the answers, "switch lanes if possible" and "lane closure ahead," and showed no significant difference (p-value 0.87 and 0.44, respectively). Therefore, these respondents reacted to the arrow board itself and not the flashing light configuration.

Summary

There was little difference in driver comprehension between the Dancing Diamonds, Flashing Diamonds, and Flashing Box displays. Drivers think Dancing Diamonds best prompt safe driving (54%), with Flashing Diamonds as a close second (43%). The Flashing Box display received the remaining 3%. Nothing about previous survey questions, driving experience outside Utah, driving time per day, or gender affected these percentages. Also, there is no significant evidence that a Diamond display was confused for a directional display more than the Flashing Box display.

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8. CONCLUSIONS

Before 2001, past literature lacked significant statistical support for any one type of caution display. Consequently, caution display standards have been set using professional judgment only. A 2001 ODOT study suggests that the Dancing Diamonds display performs in the field as well as, if not better than, other caution displays. ODOT also found that local citizens preferred the Dancing Diamonds over other caution displays. However, additional research was needed to confirm their findings.

This field experiment was conducted to obtain statistically significant evaluations for caution displays. The results of this field experiment show that the Dancing Diamonds display is associated with a statistically significant 2 mph reduction in mean speeds, whereas the Flashing Box display is associated with no statistically significant reduction in mean speeds. Lane migration analysis was inconclusive for urban freeway sites, but showed no unsafe lane migration in rural highway sites due to either caution display. No observed conflicts or hard-braking was associated with either caution display.

Regardless of caution display type, most of the 412 survey respondents would "slow down" upon seeing any caution display, and they understood the meaning to be "use caution ahead." A majority of drivers (54%) thought that the Dancing Diamonds would best prompt safe driving, followed by the Flashing Diamonds (43%) and the Flashing Box (3%). These responses did not significantly differ even when adjusted for out-of-state driving experience, driving experience per workday, gender, and bias from previous questions. At getting attention, 94% said the Flashing Box was the least effective.

This study confirms ODOT's findings of the effectiveness of the Dancing Diamonds display. The Dancing Diamonds display causes drivers to slow down cautiously and is considered by drivers to be better at promoting safe driving near highway work. The Flashing Box display has little effect on driving near highway work and is considered less effective by the driving population.

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9. RECOMMENDATIONS

At the very least, it is recommended that the Dancing Diamonds caution display be allowed in the MUTCD. Though the Flashing Box appears to be ineffectual, further studies should validate this before prohibiting its use. Further field tests are also needed to determine the effectiveness of the Flashing Diamonds and Bar displays.

Research should also be done to determine if side to side lights, such as those used in railroad beacons, school zone beacons, and the Dancing Diamonds display, are better at catching the attention of the driver.

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APPENDIX A: FIELD EXPERIMENT DATA

Table A1 – Field Experiment Speed Data

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Urban	1	1	Tue	Day	BX	65.9	1391
S1	Urban	1	1	Tue	Day	BX	N/A	N/A
AB	Urban	1	1	Tue	Day	BX	68.6	1444
FF	Urban	1	1	Tue	Night	BX	66.9	145
S1	Urban	1	1	Tue	Night	BX	63.7	85
AB	Urban	1	1	Tue	Night	BX	69.6	150
FF	Urban	1	2	Tue	Day	DD	73.5	946
S1	Urban	1	2	Tue	Day	DD	63.2	33
AB	Urban	1	2	Tue	Day	DD	N/A	N/A
FF	Urban	1	2	Tue	Night	DD	65.3	111
S1	Urban	1	2	Tue	Night	DD	62.4	7
AB	Urban	1	2	Tue	Night	DD	63.2	50
FF	Urban	2	1	Wed	Day	BX	64.3	1645
S1	Urban	2	1	Wed	Day	BX	61.3	91
AB	Urban	2	1	Wed	Day	BX	63.4	63
FF	Urban	2	1	Wed	Night	BX	65.7	95
S1	Urban	2	1	Wed	Night	BX	64.6	43
AB	Urban	2	1	Wed	Night	BX	61.5	21
FF	Urban	2	2	Wed	Day	DD	63.3	1191
S1	Urban	2	2	Wed	Day	DD	61.7	1183
AB	Urban	2	2	Wed	Day	DD	62.6	1234
FF	Urban	2	2	Wed	Night	DD	64.0	66
S1	Urban	2	2	Wed	Night	DD	63.8	56
AB	Urban	2	2	Wed	Night	DD	62.3	37
FF	Urban	3	1	Thu	Day	DD	65.5	1674
S1	Urban	3	1	Thu	Day	DD	67.2	18
AB	Urban	3	1	Thu	Day	DD	N/A	N/A
FF	Urban	3	1	Thu	Night	DD	68.1	142
S1	Urban	3	1	Thu	Night	DD	62.2	8
AB	Urban	3	1	Thu	Night	DD	57.4	29
FF	Urban	3	2	Thu	Day	BX	64.8	1746
S1	Urban	3	2	Thu	Day	BX	69.0	1484
AB	Urban	3	2	Thu	Day	BX	N/A	N/A
FF	Urban	3	2	Thu	Night	BX	66.2	144
S1	Urban	3	2	Thu	Night	BX	67.2	120
AB	Urban	3	2	Thu	Night	BX	N/A	N/A
FF	Urban	4	1	Tue	Day	None	65.2	6
S1	Urban	4	1	Tue	Day	None	59.7	4
AB	Urban	4	1	Tue	Day	None	66.3	960
FF	Urban	4	1	Tue	Night	DD	66.5	1
S1	Urban	4	1	Tue	Night	DD	N/A	N/A
AB	Urban	4	1	Tue	Night	DD	65.4	34

Table A1 – Field Experiment Speed Data (Continued)

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Urban	4	2	Tue	Day	BX	67.3	16
S1	Urban	4	2	Tue	Day	BX	56.5	32
AB	Urban	4	2	Tue	Day	BX	63.8	1058
FF	Urban	4	2	Tue	Night	BX	73.3	1
S1	Urban	4	2	Tue	Night	BX	61.2	4
AB	Urban	4	2	Tue	Night	BX	62.1	23
FF	Urban	5	1	Thu	Day	BX	59.6	2
S1	Urban	5	1	Thu	Day	BX	61.8	1455
AB	Urban	5	1	Thu	Day	BX	55.0	139
FF	Urban	5	1	Thu	Night	BX	54.2	3
S1	Urban	5	1	Thu	Night	BX	60.4	78
AB	Urban	5	1	Thu	Night	BX	50.5	18
FF	Urban	6	1	Tue	Day	BX	68.4	1337
S1	Urban	6	1	Tue	Day	BX	68.5	1764
AB	Urban	6	1	Tue	Day	BX	67.7	622
FF	Urban	6	1	Wed	Night	BX	67.5	140
S1	Urban	6	1	Wed	Night	BX	68.1	293
AB	Urban	6	1	Wed	Night	BX	65.8	89
FF	Urban	6	2	Tue	Day	DD	N/A	N/A
S1	Urban	6	2	Tue	Day	DD	67.2	1804
AB	Urban	6	2	Tue	Day	DD	66.7	1241
FF	Urban	6	2	Tue	Night	DD	69.7	141
S1	Urban	6	2	Tue	Night	DD	65.6	313
AB	Urban	6	2	Tue	Night	DD	62.3	121
FF	Urban	7	1	Thu	Day	BX	66.1	1550
S1	Urban	7	1	Thu	Day	BX	64.2	1321
AB	Urban	7	1	Thu	Day	BX	62.1	1330
FF	Urban	7	1	Thu	Night	BX	68.9	167
S1	Urban	7	1	Thu	Night	BX	63.9	132
AB	Urban	7	1	Thu	Night	BX	61.3	120
FF	Urban	7	2	Thu	Day	DD	64.4	1138
S1	Urban	7	2	Thu	Day	DD	63.3	36
AB	Urban	7	2	Thu	Day	DD	62.2	1348
FF	Urban	7	2	Thu	Night	DD	65.4	123
S1	Urban	7	2	Thu	Night	DD	59.7	2
AB	Urban	7	2	Thu	Night	DD	63.3	92
FF	Urban	8	1	Wed	Day	BX	67.9	1271
S1	Urban	8	1	Wed	Day	BX	61.9	2371
AB	Urban	8	1	Wed	Day	BX	69.4	1599
FF	Urban	8	1	Wed	Night	BX	67.6	83
S1	Urban	8	1	Wed	Night	BX	63.8	102
AB	Urban	8	1	Wed	Night	BX	61.2	60
FF	Urban	8	2	Wed	Day	DD	66.1	2079
S1	Urban	8	2	Wed	Day	DD	64.2	2345
AB	Urban	8	2	Wed	Day	DD	60.8	616
FF	Urban	8	2	Wed	Night	DD	67.7	89
S1	Urban	8	2	Wed	Night	DD	66.4	81
AB	Urban	8	2	Wed	Night	DD	59.3	17

Table A1 – Field Experiment Speed Data (Continued)

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Urban	9	1	Tue	Day	DD	68.8	5
S1	Urban	9	1	Tue	Day	DD	66.1	1207
AB	Urban	9	1	Tue	Day	DD	64.1	172
FF	Urban	9	1	Tue	Night	DD	63.0	3
S1	Urban	9	1	Tue	Night	DD	61.2	24
AB	Urban	9	1	Tue	Night	DD	58.0	6
FF	Urban	9	2	Tue	Day	BX	67.6	792
S1	Urban	9	2	Tue	Day	BX	69.0	760
AB	Urban	9	2	Tue	Day	BX	69.6	1094
FF	Urban	9	2	Tue	Night	BX	65.4	21
S1	Urban	9	2	Tue	Night	BX	67.6	22
AB	Urban	9	2	Tue	Night	BX	69.6	23
FF	Urban	10	1	Wed	Day	BX	58.5	2
S1	Urban	10	1	Wed	Day	BX	56.2	3
AB	Urban	10	1	Wed	Day	BX	63.4	990
FF	Urban	10	1	Wed	Night	BX	N/A	N/A
S1	Urban	10	1	Wed	Night	BX	N/A	N/A
AB	Urban	10	1	Wed	Night	BX	63.1	23
FF	Urban	10	2	Thu	Day	DD	56.0	481
S1	Urban	10	2	Thu	Day	DD	69.5	976
AB	Urban	10	2	Thu	Day	DD	63.3	948
FF	Urban	10	2	Thu	Night	DD	57.8	26
S1	Urban	10	2	Thu	Night	DD	68.1	21
AB	Urban	10	2	Thu	Night	DD	64.2	20
FF	Urban	11	1	Tue	Day	BX	N/A	N/A
S1	Urban	11	1	Tue	Day	BX	N/A	N/A
AB	Urban	11	1	Tue	Day	BX	N/A	N/A
FF	Urban	11	1	Tue	Night	BX	N/A	N/A
S1	Urban	11	1	Tue	Night	BX	63.4	53
AB	Urban	11	1	Tue	Night	BX	N/A	N/A
FF	Urban	12	1	Wed	Day	DD	N/A	N/A
S1	Urban	12	1	Wed	Day	DD	62.6	1866
AB	Urban	12	1	Wed	Day	DD	62.9	1726
FF	Urban	12	1	Wed	Night	DD	N/A	N/A
S1	Urban	12	1	Wed	Night	DD	63.9	121
AB	Urban	12	1	Wed	Night	DD	62.7	91
FF	Urban	12	2	Wed	Day	BX	64.0	2100
S1	Urban	12	2	Wed	Day	BX	62.5	82
AB	Urban	12	2	Wed	Day	BX	65.6	1631
FF	Urban	12	2	Wed	Night	BX	66.8	174
S1	Urban	12	2	Wed	Night	BX	62.6	22
AB	Urban	12	2	Wed	Night	BX	65.7	69
FF	Rural	13	1	Wed	Day	BX	53.3	537
S1	Rural	13	1	Wed	Day	BX	52.2	304
AB	Rural	13	1	Wed	Day	BX	49.8	541
FF	Rural	13	1	Wed	Night	BX	55.4	278
S1	Rural	13	1	Wed	Night	BX	54.5	236
AB	Rural	13	1	Wed	Night	BX	52.6	283

Table A1 – Field Experiment Speed Data (Continued)

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Rural	13	2	Tue	Day	DD	55.8	559
S1	Rural	13	2	Tue	Day	DD	55.3	281
AB	Rural	13	2	Tue	Day	DD	53.4	552
FF	Rural	13	2	Tue	Night	DD	54.8	300
S1	Rural	13	2	Tue	Night	DD	55.1	255
AB	Rural	13	2	Tue	Night	DD	53.7	304
FF	Rural	14	1	Tue	Day	DD	N/A	N/A
S1	Rural	14	1	Tue	Day	DD	57.2	107
AB	Rural	14	1	Tue	Day	DD	N/A	N/A
FF	Rural	14	1	Tue	Night	DD	N/A	N/A
S1	Rural	14	1	Tue	Night	DD	53.3	110
AB	Rural	14	1	Tue	Night	DD	N/A	N/A
FF	Rural	14	2	Wed	Day	BX	55.5	127
S1	Rural	14	2	Wed	Day	BX	58.4	21
AB	Rural	14	2	Wed	Day	BX	55.8	128
FF	Rural	14	2	Wed	Night	BX	55.0	132
S1	Rural	14	2	Wed	Night	BX	56.8	50
AB	Rural	14	2	Wed	Night	BX	56.2	130
FF	Rural	15	1	Thu	Day	DD	59.8	675
S1	Rural	15	1	Thu	Day	DD	57.9	199
AB	Rural	15	1	Thu	Day	DD	56.5	661
FF	Rural	15	1	Thu	Night	DD	57.3	380
S1	Rural	15	1	Thu	Night	DD	57.3	233
AB	Rural	15	1	Thu	Night	DD	56.2	355
FF	Rural	15	2	Thu	Day	BX	57.9	2
S1	Rural	15	2	Thu	Day	BX	57.0	666
AB	Rural	15	2	Thu	Day	BX	52.0	24
FF	Rural	15	2	Thu	Night	BX	46.3	1
S1	Rural	15	2	Thu	Night	BX	56.8	342
AB	Rural	15	2	Thu	Night	BX	53.7	8
FF	Rural	16	1	Wed	Day	BX	N/A	N/A
S1	Rural	16	1	Wed	Day	BX	N/A	N/A
AB	Rural	16	1	Wed	Day	BX	58.4	214
FF	Rural	16	1	Wed	Night	BX	N/A	N/A
S1	Rural	16	1	Wed	Night	BX	N/A	N/A
AB	Rural	16	1	Wed	Night	BX	58.1	92
FF	Rural	16	2	Wed	Day	DD	57.0	3
S1	Rural	16	2	Wed	Day	DD	N/A	N/A
AB	Rural	16	2	Wed	Day	DD	59.0	168
FF	Rural	16	2	Wed	Night	DD	53.8	14
S1	Rural	16	2	Wed	Night	DD	N/A	N/A
AB	Rural	16	2	Wed	Night	DD	56.3	79
FF	Rural	17	1	Thu	Day	BX	58.5	73
S1	Rural	17	1	Thu	Day	BX	57.3	925
AB	Rural	17	1	Thu	Day	BX	N/A	N/A
FF	Rural	17	1	Thu	Night	BX	54.1	169
S1	Rural	17	1	Thu	Night	BX	53.7	496
AB	Rural	17	1	Thu	Night	BX	53.6	1

Table A1 – Field Experiment Speed Data (Continued)

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Rural	17	2	Wed	Day	DD	42.3	2
S1	Rural	17	2	Wed	Day	DD	57.8	779
AB	Rural	17	2	Wed	Day	DD	57.8	202
FF	Rural	17	2	Wed	Night	DD	N/A	N/A
S1	Rural	17	2	Wed	Night	DD	54.5	251
AB	Rural	17	2	Wed	Night	DD	55.1	150
FF	Rural	18	1	Thu	Day	DD	59.0	48
S1	Rural	18	1	Thu	Day	DD	53.2	79
AB	Rural	18	1	Thu	Day	DD	43.0	2
FF	Rural	18	1	Thu	Night	DD	57.4	19
S1	Rural	18	1	Thu	Night	DD	54.3	21
AB	Rural	18	1	Thu	Night	DD	N/A	N/A
FF	Rural	18	2	Wed	Day	BX	57.1	18
S1	Rural	18	2	Wed	Day	BX	55.3	77
AB	Rural	18	2	Wed	Day	BX	64.2	3
FF	Rural	18	2	Wed	Night	BX	57.9	19
S1	Rural	18	2	Wed	Night	BX	55.5	25
AB	Rural	18	2	Wed	Night	BX	N/A	N/A
FF	Rural	19	1	Wed	Day	DD	53.4	39
S1	Rural	19	1	Wed	Day	DD	50.4	89
AB	Rural	19	1	Wed	Day	DD	49.9	3
FF	Rural	19	1	Wed	Night	DD	55.2	21
S1	Rural	19	1	Wed	Night	DD	48.1	34
AB	Rural	19	1	Wed	Night	DD	46.7	1
FF	Rural	19	2	Tue	Day	BX	56.4	43
S1	Rural	19	2	Tue	Day	BX	51.6	69
AB	Rural	19	2	Tue	Day	BX	N/A	N/A
FF	Rural	19	2	Tue	Night	BX	55.9	27
S1	Rural	19	2	Tue	Night	BX	49.4	35
AB	Rural	19	2	Tue	Night	BX	47.7	1
FF	Rural	20	1	Thu	Day	DD	39.3	2
S1	Rural	20	1	Thu	Day	DD	51.9	2
AB	Rural	20	1	Thu	Day	DD	54.9	710
FF	Rural	20	1	Thu	Night	DD	47.4	1
S1	Rural	20	1	Thu	Night	DD	49.6	13
AB	Rural	20	1	Thu	Night	DD	51.1	711
FF	Rural	20	2	Tue	Day	BX	56.9	61
S1	Rural	20	2	Tue	Day	BX	57.8	640
AB	Rural	20	2	Tue	Day	BX	N/A	N/A
FF	Rural	20	2	Tue	Night	BX	58.5	431
S1	Rural	20	2	Tue	Night	BX	56.6	561
AB	Rural	20	2	Tue	Night	BX	N/A	N/A
FF	Rural	21	1	Tue	Day	BX	N/A	N/A
S1	Rural	21	1	Tue	Day	BX	N/A	N/A
AB	Rural	21	1	Tue	Day	BX	57.9	122
FF	Rural	21	1	Tue	Night	BX	N/A	N/A
S1	Rural	21	1	Tue	Night	BX	N/A	N/A
AB	Rural	21	1	Tue	Night	BX	58.5	85

Table A1 – Field Experiment Speed Data (Continued)

Where	LocType	Loc	Order	Day	Time	Type	AvgSpeed	N
FF	Rural	21	2	Wed	Day	DD	56.9	121
S1	Rural	21	2	Wed	Day	DD	56.6	1
AB	Rural	21	2	Wed	Day	DD	59.3	43
FF	Rural	21	2	Wed	Night	DD	56.6	89
S1	Rural	21	2	Wed	Night	DD	N/A	N/A
AB	Rural	21	2	Wed	Night	DD	61.4	61
FF	Rural	22	1	Wed	Day	BX	N/A	N/A
S1	Rural	22	1	Wed	Day	BX	N/A	N/A
AB	Rural	22	1	Wed	Day	BX	58.4	163
FF	Rural	22	1	Wed	Night	BX	54.1	1
S1	Rural	22	1	Wed	Night	BX	N/A	N/A
AB	Rural	22	1	Wed	Night	BX	56.6	81
FF	Rural	22	2	Thu	Day	DD	62.3	39
S1	Rural	22	2	Thu	Day	DD	N/A	N/A
AB	Rural	22	2	Thu	Day	DD	59.7	195
FF	Rural	22	2	Thu	Night	DD	56.3	46
S1	Rural	22	2	Thu	Night	DD	N/A	N/A
AB	Rural	22	2	Thu	Night	DD	55.5	68

Table A2 - Field Experiment (Urban) Lane Migration/Brakelight Data

Loc	Type	Order	Volume	L to R	R to L	# Brake	%L to R	%R to L	%Brake
3	DD	1	1358	144	233	21	10.6%	17.2%	1.5%
3	BX	2	1297	139	236	18	10.7%	18.2%	1.4%
6	BX	1	1507	36	177	3	2.4%	11.7%	0.2%
6	DD	2	1406	18	155	0	1.3%	11.0%	0.0%
12	DD	1	1896	124	233	50	6.5%	12.3%	2.6%
12	BX	2	1806	170	219	10	9.4%	12.1%	0.6%

Table A3 - Field Experiment (Rural) Lane Migration/Brakelight Data

Loc	Type	Order	Date	Day	Time	# Brake	Comments
14	DD	1	7/10	Tue	Day	2	Impatient vehicle
14	DD	1	7/10	Tue	Night	6	Brake taps
13	BX	1	7/11	Wed	Day	33	High volume, plattooning
13	BX	1	7/11	Wed	Night	6	Plattoning
13	DD	2	7/17	Tue	Day	60	Plattoning
13	DD	2	7/17	Tue	Night	35	Plattoning, passing
14	BX	2	7/18	Wed	Day	5	
14	BX	2	7/18	Wed	Night	5	
15	DD	1	7/19	Thu	Day	65	Passing
15	DD	1	7/19	Thu	Night	39	Plattoning
16	BX	1	7/25	Wed	Day	11	One car drove around tubes
16	BX	1	7/25	Wed	Night	9	
15	BX	2	7/26	Thu	Day	61	Plattoning
15	BX	2	7/26	Thu	Night	20	
16	DD	2	8/1	Wed	Day	11	Some plattoning

Table A3 - Field Experiment (Rural) Lane Migration/Brakelight Data (Continued)

Loc	Type	Order	Date	Day	Time	# Brake	Comments
16	DD	2	8/1	Wed	Night	6	Lots of passing
17	BX	1	8/2	Thu	Day	29	Heavy vehicle plattoning
17	BX	1	8/2	Thu	Night	47	
21	BX	1	8/21	Tue	Day	7	Passing
21	BX	1	8/21	Tue	Night	4	
22	BX	1	8/22	Wed	Day	9	Passing
22	BX	1	8/22	Wed	Night	5	
20	DD	1	8/23	Thu	Day	51	Plattoning
20	DD	1	8/23	Thu	Night	128	
20	BX	2	8/28	Tue	Day	65	
20	BX	2	8/28	Tue	Night	73	Passing
21	DD	2	8/29	Wed	Day	6	
21	DD	2	8/29	Wed	Night	3	
22	DD	2	8/30	Thu	Day	6	Passing
22	DD	2	8/30	Thu	Night	1	Very little volume
17	DD	2	9/5	Wed	Day	34	Passing
17	DD	2	9/5	Wed	Night	6	Very windy and dusty
19	DD	1	9/12	Wed	Day	0	Passing
19	DD	1	9/12	Wed	Night	1	
18	DD	1	9/13	Thu	Day	3	
18	DD	1	9/13	Thu	Night	1	
19	BX	2	9/18	Tue	Day	3	One car drove around tubes
19	BX	2	9/18	Tue	Night	2	
18	BX	2	9/19	Wed	Day	6	
18	BX	2	9/19	Wed	Night	1	

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APPENDIX B: COMPREHENSION/OPINION SURVEY DATA

Table B1 – Summary of Survey Data

			Form AD		*Form FD*		*Form FB*	
Code	**Q#**	**Response**	**Totals**	**%'s**	**Totals**	**%'s**	**Totals**	**%'s**
0A		Respondent	138		137		137	
1A	**Q1**	Switch lanes if possible	40	29%	37	27%	36	26%
1B		Slow down	63	46%	75	55%	64	47%
1C		Pay more attention	18	13%	14	10%	21	15%
1D		Continue normal driving	10	7%	1	1%	12	9%
1E		Look for highway work	7	5%	10	7%	4	3%
2A	**Q2**	Shoulder work ahead	24	17%	13	9%	16	12%
2B		Use caution ahead	82	59%	92	67%	76	55%
2C		Proceed normally	1	1%	0	0%	3	2%
2D		Lane closure ahead	11	8%	10	7%	6	4%
2E		Do not know	20	14%	22	16%	36	26%
3A	**Q3**	Flashing Box	3	2%	4	3%	7	5%
3B		Alternating Diamonds	79	57%	68	50%	75	55%
3C		Flashing Diamonds	56	41%	65	47%	55	40%
4A	**Q4**	Flashing Box	133	96%	130	95%	124	91%
4B		Alternating Diamonds	1	1%	2	1%	1	1%
4C		Flashing Diamonds	2	1%	1	1%	2	1%
4D		None of them	2	1%	4	3%	10	7%
5A	**Q5**	Male	86	62%	88	64%	83	61%
5B		Female	52	38%	49	36%	54	39%
6A	**Q6**	16 to 19	14	10%	14	10%	11	8%
6B		20 to 29	44	32%	31	23%	31	23%
6C		30 to 39	22	16%	25	19%	19	14%
6D		40 to 49	27	20%	35	26%	40	29%
6E		50 to 59	13	9%	20	15%	14	10%
6F		60 to 69	14	10%	7	5%	12	9%
6G		70 +	4	3%	3	2%	9	7%
7A	**Q7**	Time per day (min)						
8A	**Q8**	State						
9A	**Q9**	County						

Form: AD FD FB .

THANK YOU!

Honestly mark the best answer (only ☑ ONE box).

1. In this situation, your *first reaction* would be to:

- ☐ Switch lanes if possible
- ☐ Slow down
- ☐ Pay more attention
- ☐ Continue normal driving
- ☐ Look for highway work

2. What does this sign mean *to you*?

- ☐ Shoulder work ahead
- ☐ Use caution ahead
- ☐ Proceed normally (Highway work has ceased for now)
- ☐ Lane closure ahead
- ☐ Do not know

3. In your opinion, which of these three signs would *best prompt safe driving* near highway work?

- ☐ Flashing Box
- ☐ Alternating Diamonds
- ☐ Flashing Diamonds

4. In your opinion, which of these three signs would *most likely be ignored*?

- ☐ Flashing Box
- ☐ Alternating Diamonds
- ☐ Flashing Diamonds
- ☐ None of them

5. Gender

- ☐ Male
- ☐ Female

6. How old are you?

- ☐ 16 to 19
- ☐ 20 to 29
- ☐ 30 to 39
- ☐ 40 to 49
- ☐ 50 to 59
- ☐ 60 to 69
- ☐ 70 +

7. How much time do you spend driving during a typical workday?

_____ hours _____ minutes

8. Which U.S. **state** have you done the most driving in?

_____ (State)

9. Which **county** have you done the most driving in?

_____ (County)

10. *Pick your candy bar and enjoy!*

Figure B1 – Comprehension/Opinion Survey Form

Table B2 – Survey Responses for Form AD

0	*1*					*2*					*3*			*4*				*5*		*6*							*7*	*8*	*9*
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
53		1				1						1		1				1				1					90	UT	Utah
50	1						1						1	1				1			1						45	CA	Nevada
47	1						1				1			1					1			1					60	CA	Orange
44		1					1						1	1					1						1		20	CA	Contra-Costa
41	1									1			1	1					1		1						120	UT	Utah
38			1				1				1			1				1			1						120	UT	Utah
35		1					1				1			1				1			1						30	CA	LA
32	1						1				1			1					1	1							60	UT	Utah
27		1					1				1			1				1				1					60	UT	Utah
26		1					1				1						1	1		1							90	UT	Utah
25					1		1				1			1				1			1						20	UT	Utah
22			1				1				1			1				1				1					60	UT	Utah
19	1						1						1	1					1		1						60	UT	Utah
16	1						1				1			1				1			1						90	UT	Utah
13		1					1				1			1					1						1		15	UT	Utah
10	1						1				1			1				1			1						90	CO	Beaver
7	1						1				1			1				1					1				120	UT	Utah
4		1					1						1	1				1					1				60	UT	Carbon
1		1				1					1			1				1							1		210	UT	Statewide
115		1					1						1	1				1			1						360	UT	Utah
113	1						1						1	1					1		1						75	UT	Utah
110		1								1			1	1					1		1						30	VA	Fauquier
106	1						1						1	1				1			1						90	UT	Utah
103					1		1						1	1					1	1							210	UT	Utah
100		1				1					1			1					1	1							60	UT	Utah
97		1					1				1			1					1		1						60	UT	Utah
94				1						1			1	1					1	1							240	UT	Utah
91		1					1				1			1					1			1					1	CA	LA
88	1					1					1			1					1	1							120	UT	Utah
83		1				1							1	1				1								1	120	UT	Utah
80	1									1	1			1					1	1							180	UT	Utah
77			1				1				1			1					1			1					70	UT	Utah
75					1					1	1			1				1			1						270	KY	Oldham
71				1			1						1	1				1		1							120	UT	Utah
68		1					1						1	1				1				1					45	UT	Utah
65			1				1						1	1				1			1						90	UT	Utah
62		1					1				1			1					1		1						120	UT	Davis
59			1				1				1			1					1		1						120	UT	Wasatch
56	1						1				1			1					1						1		60	UT	Utah
129	1						1						1	1				1		1							410	UT	?
126			1			1					1			1					1				1				15	UT	Summit
125		1					1				1			1				1					1				15	WY	Uinta
121	1								1				1	1				1			1						135	UT	Summit
119		1					1				1			1				1					1				60	WY	Sweetwater
116		1				1					1			1				1			1						90	UT	USA
145		1					1				1			1					1			1					120	UT	Salt Lake
142		1					1				1			1				1			1						80	UT	Salt Lake
141					1	1							1	1					1		1						60	UT	Salt Lake

Table B2 – Survey Responses for Form AD (Continued)

0	1					2					3			4				5		6							7	8	9
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
137		1					1					1		1				1			1						190	UT	Salt Lake
134	1						1					1		1				1				1					570	KY	Rowan
153	1						1					1		1					1				1				600	All	
150		1							1				1	1					1							1	100	CAN	Winnipeg City
146		1					1					1		1					1					1			60	ID	Blaine
167			1				1						1	1					1	1							10	ND	Burleigh
164	1					1						1		1				1		1							720	UT	Salt Lake
163		1					1				1			1				1			1						60	AZ	Maricopa
158			1				1					1		1				1			1						120	CA	Los Angelas
156		1					1						1	1				1								1	120	UT	Salt Lake
198		1				1						1		1					1		1						300	MO	Greene
195		1					1					1		1				1			1						960	All	
193				1			1						1	1				1		1							120	UT	Davis
187		1					1					1		1				1								1	60	AZ	Maricopa
183			1				1					1		1					1		1						30	UT	Davis
181		1						1				1		1				1						1			90	UT	Weber
177		1					1						1	1				1					1				90	TX	Victoria
173		1						1				1		1					1					1			45	ID	All
170			1			1						1		1				1		1							30	ID	Ada
347				1					1				1	1				1				1					1	UT	Salt Lake
345				1		1							1	1				1		1							60	UT	Utah
342		1					1					1		1				1				1					20	UT	Salt Lake
338		1					1					1		1				1								1	90	UT	Salt Lake
337	1					1							1	1					1			1					120	WA	Kitsup
332				1				1				1		1					1	1							150	UT	Salt Lake
331	1								1				1	1					1		1						120	UT	Davis
326		1								1		1				1			1	1							180	UT	Salt Lake
325	1						1						1	1					1		1						600	UT	Salt Lake
320				1			1					1		1				1				1					120	UT	Weber
319		1					1						1	1				1						1			120	UT	Davis
314		1				1							1	1				1						1			120	UT	Salt Lake
313		1					1						1	1					1			1					90	UT	Salt Lake
308	1							1					1	1				1		1							180	UT	Salt Lake
307	1								1				1	1				1								1	60	UT	Salt Lake
302			1			1						1		1					1	1							20	AZ	Pima
301		1					1					1		1				1				1					120	UT	Salt Lake
296	1								1				1				1		1			1					240	MA	Hampshire
295			1					1				1		1				1								1	20	UT	Salt Lake
290		1							1			1		1				1					1				150	UT	Salt Lake
289		1					1					1		1					1	1							120	UT	Salt Lake
285			1				1						1	1				1				1					1	UT	Salt Lake
282		1					1					1		1				1		1							90	UT	Salt Lake
279		1					1					1		1					1			1					60	CA	San Diego
277			1						1				1	1				1			1						40	CA	LA
272	1						1					1		1					1		1						105	UT	Davis
271		1					1					1		1				1					1				120	UT	Salt Lake
268				1			1					1		1				1			1						30	NY	Erie
265		1					1						1	1				1					1				60	UT	Salt Lake

Table B2 – Survey Responses for Form AD (Continued)

0	1					2					3			4				5		6							7	8	9
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
262		1					1						1	1				1							1		105	UT	Salt Lake
257		1								1			1	1				1							1		30	CA	Contra Costa
256	1						1						1	1				1		1							60	WY	Laramie
251	1								1				1	1					1							1	60	AZ	Navajo
250	1					1							1	1					1		1						60	UT	Salt Lake
245	1						1						1	1				1								1	150	UT	Salt Lake
244	1						1					1		1				1					1				120	UT	Utah
239		1								1			1	1				1					1				15	UT	Utah
238	1									1			1	1				1			1						30	UT	Salt Lake
233		1					1					1		1					1					1			90	UT	Davis
228		1					1						1	1				1			1						60	UT	Salt Lake
227	1						1					1			1			1			1						90	UT	Salt Lake
224		1					1						1	1				1			1						60	UT	Salt Lake
220	1					1						1		1				1			1						60	UT	Davis
216			1				1						1	1				1			1						120	UT	Salt Lake
215		1					1					1		1				1				1					5	UT	Utah
210				1					1				1	1					1				1				80	UT	Salt Lake
207			1							1			1	1				1						1			60	UT	Salt Lake
204		1								1		1		1				1				1					10	UT	Salt Lake
201	1						1						1	1				1				1					60	UT	Salt Lake
389		1				1						1		1				1			1						20	UT	Salt Lake
388	1						1					1		1				1				1					20	UT	Salt Lake
383		1					1					1		1					1			1					150	UT	Salt Lake
381			1							1		1				1		1			1						15	UT	Salt Lake
378			1			1						1		1				1			1						30	UT	Salt Lake
374		1							1				1	1				1				1					60	UT	Salt Lake
370		1					1					1		1				1				1					30	UT	Salt Lake
367	1						1						1	1				1			1						180	UT	Salt Lake
363		1					1						1	1				1								1	60	UT	Utah
361					1	1							1	1					1			1					60	CA	San Diego
359		1					1					1		1					1					1			30	UT	Salt Lake
355		1				1							1	1				1				1					240	CT	Tolland
351	1					1						1		1					1		1						60	UT	Utah
348		1							1			1		1				1					1				90	CA	Santa Clara
410					1		1					1		1					1				1				60	UT	Salt Lake
407	1									1		1		1					1		1						120	UT	Utah
406					1		1					1		1				1				1					120	UT	Salt Lake
403	1					1						1		1				1					1				60	UT	Salt Lake
400		1								1		1		1				1				1					120	WY	Unita
396				1						1		1		1				1				1					540	TN	All
395		1				1						1		1					1						1		90	WY	Uintah
392	1						1					1		1				1				1					720	CO	All

Table B3 – Survey Responses for Form FD

0	*1*					*2*					*3*			*4*				*5*		*6*							*7*	*8*	*9*
A	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**A**	**B**	**C**	**D**	**A**	**B**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**A**	**A**	**A**
54		1					1					1		1				1			1						45	UT	Utah
51		1					1						1		1			1						1			120	CA	Statewide
48			1				1					1		1				1		1							30	UT	Tooele
45		1					1						1	1				1		1							360	UT	Utah
42		1					1					1		1				1			1						90	UT	Utah
39	1						1					1		1				1			1						60	UT	Utah
36	1									1		1		1					1		1						70	UT	Utah
33	1						1					1		1				1			1						120	UT	Utah
30					1					1		1		1				1		1							90	UT	Utah
28		1				1							1	1				1					1				60	UT	Utah
23		1								1		1		1				1				1					30	UT	Utah
20	1						1					1		1				1								1	195	OR	Multnomah
17		1					1						1	1				1				1					60	CA	Tulare
15		1					1						1		1			1						1			120	UT	Utah
11			1				1					1		1				1				1					120	UT	Utah
8		1					1						1	1				1				1					120	UT	Salt Lake
5	1					1							1	1				1			1						90	UT	Utah
2		1					1						1	1				1			1						80	UT	Utah
114		1					1						1	1				1			1						120	UT	Utah
111	1					1						1		1					1	1							90	CA	Santa Clara
107	1							1					1	1				1				1					60	UT	Utah
104		1					1					1		1				1		1							278	UT	Utah
101		1					1					1		1				1		1							300	UT	Utah
98	1						1						1	1				1			1						60	CO	Rio Blanco
95					1		1					1		1				1			1						90	IA	Linn
92			1				1						1	1				1			1						30	AZ	Maricopa
89	1						1					1		1				1			1						60	CA	Utah
86		1				1							1	1				1				1					240	UT	Salt Lake
84	1						1						1	1				1				1					60	UT	Utah
81					1		1					1		1					1	1							180	UT	Utah
78	1									1		1		1				1			1						60	CA	Susuin
76		1								1			1	1				1					1				180	UT	Utah
72					1		1					1		1				1			1						75	UT	Utah
69	1						1					1		1				1								1	90	UT	Utah
66		1								1			1	1				1		1							30	UT	Weber
63		1					1						1	1				1				1					150	UT	Utah
60		1					1						1		1			1						1			60	CA	US
57		1				1							1	1				1				1					60	UT	Utah
132		1								1			1	1				1					1				120	UT	Daggett
130	1									1		1		1				1					1				240	MO	Knox
127		1					1						1	1				1					1				120	WY	Campbell
123		1					1						1	1				1					1				30	ID	Blaine
118	1						1					1		1				1		1							60	AZ	Coconino
117	1						1						1	1				1				1					120	AZ	Coconino
144	1						1					1		1				1		1							240	UT	Salt Lake
138					1					1		1		1				1				1					180	UT	Salt Lake
136		1					1					1		1					1	1							180	UT	Utah
133	1						1					1		1				1				1					360	KY	Rowan

Table B3 – Survey Responses for Form FD (Continued)

0	*1*					*2*					*3*			*4*				*5*		*6*						*7*	*8*	*9*
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
155		1					1					1		1				1						1			600	TX	Hidalgo
151		1					1					1		1				1				1					600	UT	All
149		1							1				1	1				1				1					60	ID	Oneida
147	1						1						1	1				1						1			190	All	
166	1									1		1		1				1		1							90	UT	Davis
165	1						1					1		1				1					1				80	UT	Salt Lake
160	1									1			1	1					1							1	60	CA	San Diego
159	1									1			1	1				1								1	270	CA	San Diego
199	1						1						1	1				1					1				600	All	
196		1					1					1		1				1			1						900	All	
194		1								1		1		1					1				1				600	All	
190		1					1					1		1				1			1						720	IL	Irquiois
188		1					1					1		1					1			1					180	UT	Davis
185		1					1					1		1				1						1			600	All	
182			1				1						1	1				1				1					600	Wst	
179		1					1					1		1					1				1				240	UT	Weber
178					1	1							1	1				1				1					600	All	
174		1								1			1	1				1				1					540	TX	All
171		1					1						1				1	1					1				60	UT	Salt Lake
344	1					1							1	1				1		1							60	UT	Utah
340		1					1						1	1				1			1						30	UT	Salt Lake
339		1					1					1		1					1				1				90	UT	Salt Lake
334	1						1						1	1				1		1							270	UT	Salt Lake
333				1			1					1		1				1			1						60	UT	Davis
328	1						1						1	1					1				1				120	UT	Salt Lake
327	1								1				1	1					1				1				60	WI	Sheboygan
322				1			1						1	1				1									120	UT	Salt Lake
321	1					1							1	1					1			1					240	CA	LA
316		1					1						1	1				1					1				40	UT	Salt Lake
315		1					1					1		1				1				1					60	UT	Davis
310			1							1		1		1				1					1				60	UT	Davis
309		1					1					1		1				1				1					90	UT	Salt Lake
304		1								1			1	1				1					1				60	UT	Utah
303		1							1				1	1				1				1					90	UT	Salt Lake
298		1					1					1		1					1			1					20	UT	Salt Lake
297	1								1			1		1					1					1			60	CA	San Diego
292		1				1						1		1				1					1				120	UT	Weber
291	1						1						1	1					1				1				270	UT	Weber
287		1								1			1	1					1		1						60	MI	Kalamazoo
284		1					1						1	1				1						1			80	CA	LA
281			1							1		1		1				1		1							130	UT	Salt Lake
278		1					1					1		1				1				1					32	UT	Salt Lake
275		1					1						1	1				1					1				120	UT	Salt Lake
273		1					1					1		1				1					1				90	UT	Salt Lake
269		1					1						1	1					1			1					90	UT	Davis
266		1				1							1	1					1		1						15	TN	Davidson
264		1					1					1		1				1			1						60	UT	Salt Lake
259		1					1					1		1				1					1				60	UT	Salt Lake

Table B3 – Survey Responses for Form FD (Continued)

0	1					2					3			4				5		6						7	8	9
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
258		1					1					1		1				1						1			60	UT	Salt Lake
253			1				1						1	1					1				1				180	UT	Salt Lake
252		1								1		1		1				1							1		120	TX	Grayson
247		1								1			1	1				1					1				60	HI	Honolulu
246		1					1					1		1				1							1		60	UT	Salt Lake
241				1			1						1	1					1			1					120	UT	Davis
240		1					1					1		1					1	1							120	UT	Salt Lake
235			1				1						1	1				1				1					120	UT	Davis
234		1					1						1	1					1				1				180	UT	Toole
230		1								1		1		1				1				1					60	PA	Bucks
229			1				1					1		1					1			1					90	UT	Salt Lake
225		1					1						1	1				1				1					30	UT	Salt Lake
221		1					1						1	1				1					1				60	UT	Salt Lake
219	1						1					1		1					1	1							60	UT	Salt Lake
217		1					1						1	1				1						1			60	UT	Davis
211		1					1				1			1				1					1				150	UT	Salt Lake
209		1					1					1		1				1						1			15	UT	Davis
206	1					1						1					1	1					1				330	UT	Utah
202		1					1					1		1				1						1			50	UT	Davis
390	1								1			1		1				1		1							60	UT	Salt Lake
385		1							1			1		1				1					1				300	UT	Salt Lake
384		1							1				1				1	1						1			420	Wst	
380			1						1		1						1	1									241	UT	Salt Lake
377					1		1						1	1				1		1							30	UT	Salt Lake
375	1						1					1		1				1					1				240	ID	Power
371		1					1					1		1				1						1			45	UT	Salt Lake
368		1					1					1		1				1		1							150	UT	Salt Lake
365	1					1							1	1					1				1				30	UT	Salt Lake
364	1						1						1	1				1				1					10	UT	Salt Lake
360			1							1			1	1				1				1					10	UT	Salt Lake
356					1	1						1		1				1		1							300	CA	Orange
353		1					1						1	1				1					1				120	UT	Salt Lake
352		1					1						1	1				1						1			300	UT	Salt Lake
349			1				1						1	1				1				1					210	CA	LA
412	1						1						1	1				1		1							30	UT	Utah
409			1				1						1	1				1		1							60	UT	Salt Lake
405			1						1				1	1					1				1				30	UT	Salt Lake
401		1					1					1		1				1						1			600	All	
399		1					1						1	1				1		1							390	All	
397		1					1					1		1				1								1	60	UT	Utah
393		1					1					1		1				1		1							180	WY	Sweetwater

Table B4 – Survey Responses for Form FB

0	1					2					3			4				5		6							7	8	9
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
55	1								1			1		1				1			1							720	UT	Utah
52		1					1						1	1					1	1								60	CA	Santa Clara
49			1				1					1		1					1			1					120	UT	Utah
46		1					1						1	1				1		1							270	UT	Utah
43		1							1			1		1					1	1							60	UT	Utah
40			1						1			1		1					1		1						60	UT	Utah
37				1					1			1		1					1		1						120	UT	Utah
34	1						1					1		1					1		1						60	UT	Utah
31	1					1						1					1	1			1						50	CA	Fresno
29	1					1						1		1				1		1							120	UT	Utah
24		1					1						1	1					1					1			60	UT	Utah
21		1					1						1	1				1					1				120	UT	Utah
18	1						1					1		1				1								1	120	OR	Multnomah
14		1					1					1		1				1		1							60	UT	Utah
12			1						1				1	1				1				1				140	CA	US
9			1						1				1	1				1			1					120	UT	Utah
6			1				1				1			1					1		1						120	UT	Utah
3		1				1						1		1					1		1						30	UT	Utah
112			1				1						1	1					1						1		120	UT	Davis
109	1								1				1	1					1					1			150	UT	Utah
108	1					1						1		1					1		1						30	UT	Utah
105		1					1						1	1					1						1		30	UT	Utah
102		1				1							1	1					1							1	30	UT	Utah
99		1							1			1		1				1			1						90	UT	Utah
96	1						1						1	1					1		1						30	CA	El Dorado
93	1					1							1			1			1			1					140	UT	Utah
90		1							1			1		1				1		1							60	UT	Utah
87		1							1			1		1				1			1						30	UT	Utah
85			1				1						1	1				1		1							180	UT	Utah
82		1					1					1		1					1				1				90	UT	Utah
79			1				1						1	1				1					1				720	OR	Baker
74				1		1						1		1				1			1						240	UT	Utah
73				1		1							1	1					1		1						120	CA	Tulare
70		1					1						1	1				1				1					240	UT	Utah
67		1					1						1	1				1					1				75	UT	Utah
64	1								1			1		1					1	1							240	CA	Riverside
61		1					1					1		1					1				1				180	UT	Utah
58				1			1					1		1					1				1				180	UT	Carbon
131		1					1					1		1				1						1			120	UT	Daggett
128		1					1					1		1				1						1			180	UT	Salt Lake
124			1				1					1		1				1					1				600	Wst	
122		1					1					1		1				1					1				630	All	All
120		1					1				1						1	1					1				480	Wst	
143		1					1					1		1					1		1						360	UT	Salt Lake
140	1								1			1		1					1			1					600	UT	Salt Lake
139		1					1					1		1				1					1				270	UT	Salt Lake
135	1						1						1	1				1						1			10	UT	Washington

Table B4 – Survey Responses for Form FB (Continued)

0	*1*					*2*					*3*			*4*				*5*		*6*							*7*	*8*	*9*
A	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**A**	**B**	**C**	**D**	**A**	**B**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**A**	**A**	**A**
154		1								1	1				1			1								1	120	UT	Box Elder
152		1							1			1		1				1					1				60	NY	Manhattan
148		1					1					1					1	1							1		120	FL	Palm Beach
168		1								1		1		1					1		1						210	UT	Utah
162		1					1					1		1				1			1						181	UT	Salt Lake
161	1									1		1		1				1				1					240	UT	Salt Lake
157		1							1				1	1				1				1					120	UT	Salt Lake
200		1					1						1	1				1			1						5	ID	Bannock
197	1					1						1		1				1				1					600	TX	Torrent
192	1									1		1		1				1		1							270	UT	Davis
191	1								1			1					1	1								1	480	Wst	
189		1					1						1	1				1					1				120	WY	Sweetwater
186	1						1					1		1				1					1				600	CA	All
184		1					1					1		1				1				1					30	UT	Davis
180		1					1					1		1				1					1				180	UT	Weber
176		1								1			1	1					1						1		120	WY	Sweetwater
175			1							1	1						1	1							1		1	WY	
172		1					1					1		1				1							1		90	ID	All
169		1					1					1		1				1							1		120	UT	Davis
346		1					1					1		1				1		1							180	UT	Davis
343		1				1					1						1	1									120	NY	Queens
341	1						1					1		1				1					1				390	UT	All
336	1						1						1	1					1			1					60	CA	San Diego
335				1						1		1		1				1			1						120	UT	Salt Lake
330	1						1						1	1					1				1				180	UT	Salt Lake
329	1						1					1		1					1				1				60	CA	LA
324		1								1			1	1					1				1				120	UT	Summit
323		1								1			1	1					1				1				60	UT	Salt Lake
318			1				1					1		1				1				1					30	UT	Utah
317		1					1					1				1			1			1					15	UT	Salt Lake
312		1								1	1						1	1					1				60	UT	Salt Lake
311			1				1					1		1				1					1				120	UT	Salt Lake
306		1						1				1		1				1					1				1	UT	Salt Lake
305			1				1					1		1				1			1						90	UT	Salt Lake
300		1				1						1		1					1		1						60	UT	Salt Lake
299			1				1					1		1				1							1		90	UT	Salt Lake
294		1								1			1	1				1					1				80	UT	Salt Lake
293	1						1						1	1					1				1				60	UT	Salt Lake
288				1			1						1	1					1	1							120	UT	Salt Lake
286		1					1					1		1					1					1			60	UT	Salt Lake
283	1						1						1	1					1				1				20	UT	Salt Lake
280			1					1					1	1					1					1			120	UT	Utah
276			1							1		1		1				1					1				240	UT	Salt Lake
274	1						1						1	1				1					1				120	UT	Salt Lake
270			1							1			1	1				1				1					90	UT	Salt Lake
267		1								1			1	1					1		1						45	UT	Salt Lake
263					1					1	1			1				1								1	60	ME	Kennebec
261					1		1					1		1				1					1				90	UT	Davis

Table B4 – Survey Responses for Form FB (Continued)

0	1					2					3			4				5		6						7	8	9
A	A	B	C	D	E	A	B	C	D	E	A	B	C	A	B	C	D	A	B	A	B	C	D	E	F	G	A	A	A
260		1					1						1	1				1					1				95	UT	Salt Lake
255		1				1						1		1					1			1					30	UT	Salt Lake
254			1							1		1		1				1					1				120	UT	Salt Lake
249				1			1					1		1				1							1		360	UT	Salt Lake
248			1				1					1		1					1				1				45	UT	Salt Lake
243				1			1						1	1				1		1							60	UT	Salt Lake
242				1						1			1	1					1				1				60	UT	Davis
237		1					1					1		1				1			1						25	OR	Coos
236		1					1					1		1				1			1						120	UT	Salt Lake
232		1							1			1		1				1					1				30	CO	Lamar
231		1					1					1		1					1			1					30	UT	Salt Lake
226		1					1						1	1				1		1							60	UT	Salt Lake
223				1						1			1	1				1		1							30	UT	Utah
222		1				1						1		1				1								1	60	UT	Tooele
218			1				1						1	1					1	1							30	UT	Cache
214		1				1							1	1					1			1					180	UT	Salt Lake
213	1						1					1		1				1								1	60	UT	Salt Lake
212		1					1						1	1				1			1						900	AZ	Maricopa
208	1					1							1	1					1			1					120	UT	Salt Lake
205			1				1					1					1		1	1							210	UT	Utah
203	1					1							1	1				1							1		30	UT	Salt Lake
391		1					1					1		1				1				1					480	UT	Salt Lake
387	1						1					1		1				1				1					40	UT	Salt Lake
386		1					1						1	1					1			1					40	UT	Salt Lake
382	1						1					1		1				1		1							600	UT	All
379	1							1					1	1				1		1							360	UT	Davis
376	1						1					1		1				1		1							180	UT	Salt Lake
373		1					1						1	1					1			1					240	UT	Salt Lake
372		1								1		1		1				1								1	45	UT	Salt Lake
369		1					1						1				1		1				1				60	UT	Salt Lake
366		1					1					1		1					1			1					120	TX	Harris
362	1									1			1	1				1		1							300	UT	Wasatch
358				1						1			1	1				1							1		60	CA	Santa Clara
357			1				1					1		1				1					1				240	UT	Salt Lake
354				1						1		1					1	1								1	60	UT	Salt Lake
350	1						1					1		1				1				1					120	WY	Teton
411	1							1				1		1				1		1							80	UT	Salt Lake
408		1								1			1	1				1					1				60	UT	Salt Lake
404	1									1			1	1					1		1						60	UT	
402	1						1						1	1					1		1						60	UT	Cache
398			1						1			1		1				1				1				480	All	
394		1					1					1		1				1							1		180	WY	Uinta

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APPENDIX C: STATISTICAL ANALYSIS
(Written by Matthew Madden)

Speed Data Analysis

The speed data analysis was a quantitative study of how the different displays on an arrow board affected traffic. The primary goal was to determine which display – Dancing Diamonds (DD) or Flashing Box (BX) – resulted in slower traffic. To get a better read on this effect, the experiment was designed to control for a variety of other factors (see summary in Table C1). In order to generalize results to a wide range of localities, speed data were collected in 22 places—12 urban and 10 rural. Each location was tested across two weeks (Tuesday, Wednesday, Thursday), with one display used in the first week and the other in the second week. Speed measures were taken during both day and night. Data were collected using speed strips on the road placed in three locations: free flow traffic, at the first construction sign and at the arrow board.

Table C1 - Summary list and explanation of factors used in the speed experiment, including interaction terms included in the full model (all analyses were performed using SAS Proc GLM)

Variable Name	Description
LocType	General location: Rural or Urban
Loc(LocType)	Actual location: 22 Total (used as blocking variable nested within LocType)
Order	Order of testing: First or second week of testing
Day	Day: Tuesday, Wednesday or Thursday
Time	Time of day: Day or Night
Type	Arrow Board Sign Type: Dancing Diamonds or Flashing Box
Where1	Where speed was measured: Free Flow Traffic (1), at First Sign (2), or at Arrow Board (3)
LocType*Order	2-way Interaction
LocType*Time	2-way Interaction
LocType*Where1	2-way Interaction
LocType*Day	2-way Interaction
LocType*Type	2-way Interaction
Order*Where1	2-way Interaction
Order*Time	2-way Interaction
Type*Where1	2-way Interaction
Type*Time	2-way Interaction
Time*Where1	2-way Interaction

Model selection was performed using a backward stepping method. At first, interaction terms were tested; if the p-value was greater than 0.20, the term was dropped. This was done in a sequential manner, dropping the terms with the highest p-values first. Once all remaining interactions were significant at the 0.20 level, main effects were tested at the 0.10 level. Note that if a variable was part of a significant interaction, its main effect was automatically left in the model. The results are shown below in Tables

C2 and C3. The response variable (Y) was the average speed of cars at each speed strip. The model was weighted according to the number of cars used to obtain each average (a weighted least-squares approach).

Table C2 - List of terms that were dropped during the backward selection

Term Dropped	P-value
LocType*Where1	0.8762
Order*Time	0.7567
LocType*Order	0.5991
LocType*Time	0.5920
LocType*Day	0.3859
Time*Where1	0.2716
Day	0.1531

Table C3 - Final model with ANOVA statistics from SAS output

Final Model

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LocType	1	233261.2778	233261.2778	153.17	<.0001
Loc(LocType)	20	234799.2420	11739.9621	7.71	<.0001
Order	1	11223.5046	11223.5046	7.37	0.0073
Time	1	3062.5346	3062.5346	2.01	0.1580
Type	1	6322.8889	6322.8889	4.15	0.0431
Where1	2	15650.1166	7825.0583	5.14	0.0068
LocType*Type	1	9088.7627	9088.7627	5.97	0.0156
Order*Where1	2	15648.5579	7824.2790	5.14	0.0068
Type*Where1	2	18504.0411	9252.0206	6.08	0.0028
Time*Type	1	2980.5615	2980.5615	1.96	0.1636

At this point, we can use the model to answer a few questions of interest. These include the following:

- Where are speeds slower: rural or urban areas?
- How do speeds compare at the three speed strip locations?
- Which arrow board display results in lower speeds, DD or BX?
- To what degree do people stop reacting to arrow boards during the second week?

Table C4 displays these results. In each case, a negative estimate means that speeds were slower for the first parameter listed (e.g., on average, speeds were 8.4 mph slower in rural areas).

Table C4 - Estimates of interest from SAS output

Estimates of Interest

Parameter	Estimate	Error	t Value	Pr > |t|
Rural vs. Urban	-8.40152248	0.67885356	-12.38	<.0001
Free flow speed vs. Sign 1 speed	0.81244258	0.37774390	2.15	0.0329
Free flow speed vs. Arrow board speed	1.20904820	0.38556804	3.14	0.0020
Sign 1 speed vs. Arrow board speed	0.39660562	0.38084830	1.04	0.2992
Boxes vs. Diamonds	0.87164823	0.42778240	2.04	0.0431
Order 1 vs. Order 2	-0.85739794	0.31583309	-2.71	0.0073

Table C5 - Raw data for profile plots and corresponding difference test p-values

LSMeans Results with Pairwise Difference Test P-values

Plot 1	BX	DD
FF	60.6857	61.5989
S1	60.6969	59.9774
AB	60.8591	59.0181

P-values	FF/BX	S1/BX	AB/BX	FF/DD	S1/DD
S1/BX	0.9828				
AB/BX	0.743	0.7804			
FF/DD	0.1397	0.1197	0.2597		
S1/DD	0.2085	0.2059	0.1372	0.0075	
AB/DD	0.0028	0.0021	0.003	<.0001	0.0843

Plot 2	BX	DD
Day	60.7435	60.4788
Night	60.7289	59.2503

P-values	Day/BX	Day/DD	Night/BX
Day/DD	0.5273		
Night/BX	0.9807	0.6778	
Night/DD	0.0177	0.0538	0.0514

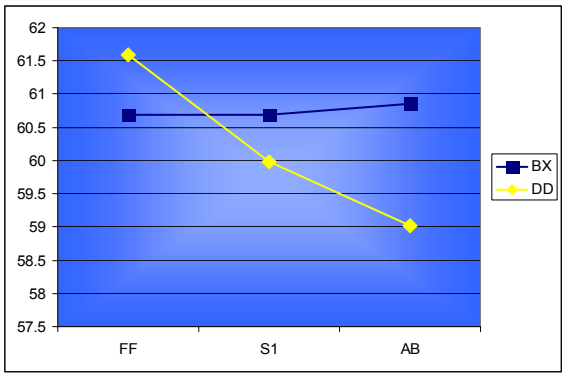
Plot 3	BX	DD
Rural	56.0627	56.1366
Urban	65.4097	63.5926

P-values	Rural/BX	Rural/DD	Urban/BX
Rural/DD	0.9072		
Urban/BX	<.0001	<.0001	
Urban/DD	<.0001	<.0001	0.0005

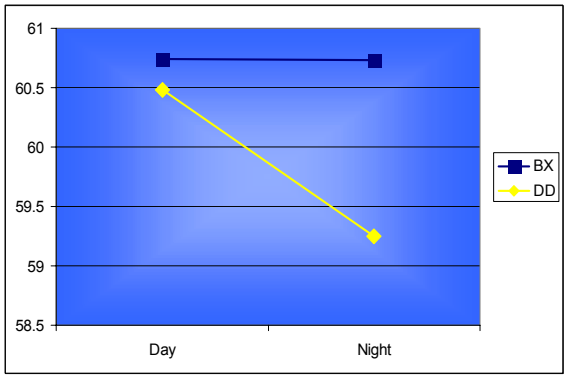
Plot 4	Order 1	Order 2
FF	61.2313	60.7171
S1	59.1477	61.1758
AB	59.2360	60.2943

P-values	FF/Order 1	S1/Order 1	AB/Order 1	FF/Order 2	S1/Order 2
S1/Order 1	0.0005				
AB/Order 1	0.0005	0.8731			
FF/Order 2	0.3544	0.0032	0.0049		
S1/Order 2	0.919	0.0003	0.0004	0.3782	
AB/Order 2	0.1235	0.0388	0.0725	0.4344	0.1289

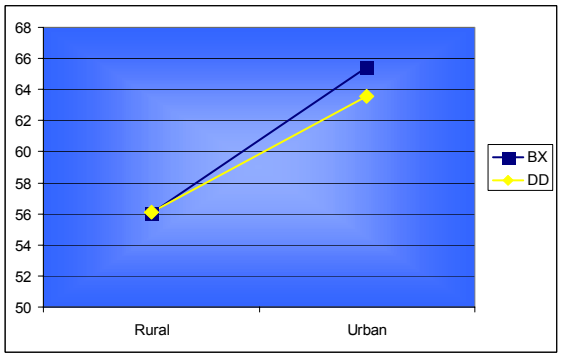
To examine other questions of interest, least-square means were calculated for certain combinations of variables. The results are displayed below in the profile plots (Figure C1).



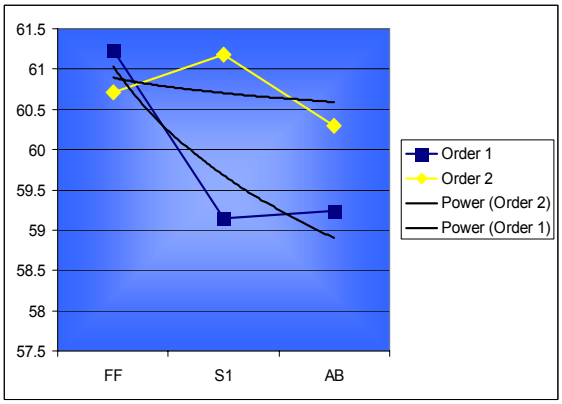
Plot 1
Profile plot of average speeds comparing type of arrow board display (BX, DD) at the three speed strip locations (Free Flow, Sign 1, Arrow Board).



Plot 2
Profile plot of average speeds comparing type of arrow board display (BX, DD) during day and night.



Plot 3
Profile plot of average speeds comparing type of arrow board display (BX, DD) at rural and urban sites.



Plot 4
Profile plot of average speeds comparing week order at the three speed strip locations (Free Flow, Sign 1, Arrow Board). Plot includes quadratic LS estimate lines.

Figure C1 – Profile Plots 1 through 4

The SAS code for the weighted least-squares model is given in Table C6. The corresponding coefficients are shown in Table C7 below.

Table C6 - SAS code for the final model

```
proc glm data=all1;
 class loc loctype order time day type where1;
 model mean1 = loctype loc(loctype) order time type where1
               loctype*type
               order*where1
               type*where1
               type*time
 / ss3 solution;
 weight n1;
 estimate 'Rural vs. Urban' loctype 1 -1 ;
 estimate 'Free flow speed vs. Sign 1 speed' where1 1 -1 0 ;
 estimate 'Free flow speed vs. Arrowboard speed' where1 1 0 -1 ;
 estimate 'Sign 1 speed vs. Arrowboard speed' where1 0 1 -1 ;
 estimate 'Boxes vs. Diamonds' type 1 -1 ;
 estimate 'Order 1 vs. Order 2' order 1 -1;
 lsmeans type*time / pdiff;
 lsmeans type*where1 / pdiff;
 lsmeans loctype*type / pdiff;
 lsmeans order*where1 / pdiff;
run;
```

Table C7- Coefficients for the final model

Parameter		Estimate	Std. Error	t Value	Pr > |t|
Intercept		61.9747	0.8493	72.9700	<.0001
LocType	Rural	-4.7042	1.7141	-2.7400	0.0067
LocType	Urban	.	.	.	.
Loc(LocType)	13 Rural	-4.9636	1.7144	-2.9000	0.0043
Loc(LocType)	14 Rural	-2.6727	2.1397	-1.2500	0.2133
Loc(LocType)	15 Rural	-1.3233	1.7622	-0.7500	0.4537
Loc(LocType)	16 Rural	-0.0018	2.2915	0.0000	0.9994
Loc(LocType)	17 Rural	-1.9311	1.7779	-1.0900	0.2789
Loc(LocType)	18 Rural	-3.2438	2.7487	-1.1800	0.2396
Loc(LocType)	19 Rural	-6.6730	2.6190	-2.5500	0.0117
Loc(LocType)	20 Rural	-2.5825	1.7836	-1.4500	0.1494
Loc(LocType)	21 Rural	-0.6184	2.3479	-0.2600	0.7925
Loc(LocType)	22 Rural	.	.	.	.
Loc(LocType)	1 Urban	3.6183	0.7821	4.6300	<.0001
Loc(LocType)	2 Urban	-1.4194	0.7165	-1.9800	0.0492
Loc(LocType)	3 Urban	0.9676	0.7778	1.2400	0.2152
Loc(LocType)	4 Urban	-1.9052	1.3233	-1.4400	0.1517
Loc(LocType)	5 Urban	-3.0016	1.1225	-2.6700	0.0082
Loc(LocType)	6 Urban	3.3246	0.6573	5.0600	<.0001
Loc(LocType)	7 Urban	-0.4562	0.6652	-0.6900	0.4937
Loc(LocType)	8 Urban	0.5806	0.6158	0.9400	0.3471
Loc(LocType)	9 Urban	3.2656	0.7657	4.2600	<.0001
Loc(LocType)	10 Urban	-0.2142	0.8191	-0.2600	0.7940
Loc(LocType)	11 Urban	-0.5509	5.4259	-0.1000	0.9192
Loc(LocType)	12 Urban	.	.	.	.
Order	1	-1.0583	0.5856	-1.8100	0.0725
Order	2	.	.	.	.
Time	Day	1.2286	0.6326	1.9400	0.0538
Time	Night	.	.	.	.
Type	BX	3.7177	1.0122	3.6700	0.0003
Type	DD	.	.	.	.
Where1	1	1.8022	0.6092	2.9600	0.0035
Where1	2	1.4424	0.5818	2.4800	0.0141
Where1	3	.	.	.	.
LocType*Type	Rural BX	-1.8910	0.7741	-2.4400	0.0156
LocType*Type	Rural DD	.	.	.	.
LocType*Type	Urban BX	.	.	.	.
LocType*Type	Urban DD	.	.	.	.
Order*Where1	1 1	1.5724	0.7875	2.0000	0.0474
Order*Where1	1 2	-0.9698	0.8351	-1.1600	0.2471
Order*Where1	1 3	.	.	.	.
Order*Where1	2 1	.	.	.	.
Order*Where1	2 2	.	.	.	.
Order*Where1	2 3	.	.	.	.
Type*Where1	BX 1	-2.7587	0.7970	-3.4600	0.0007
Type*Where1	BX 2	-1.1218	0.8325	-1.3500	0.1796
Type*Where1	BX 3	.	.	.	.
Type*Where1	DD 1	.	.	.	.
Type*Where1	DD 2	.	.	.	.
Type*Where1	DD 3	.	.	.	.
Time*Type	Day BX	-1.2140	0.8678	-1.4000	0.1636
Time*Type	Day DD	.	.	.	.
Time*Type	Night BX	.	.	.	.
Time*Type	Night DD	.	.	.	.

Survey Data Analysis

The survey data were used to elicit attitudinal responses to three different types of arrow board displays:

1. Dancing Diamonds (DD) (also called Alternating Diamonds)
2. Flashing Diamonds (FD)
3. Flashing Box (BX)

In all, 412 people were randomly sampled. Three forms were used, each corresponding to one of the displays. Depending on the form, each person was shown a video clip of a sign display and asked a series of questions, including demographics.

Below (Figure C2) are the complete results of the chi-square tests mentioned in the body of the paper. The output is ordered from question 1 to question 3. Please note that log-linear models were considered for these tests; however, the chi-square results were clear enough that the extra modeling would not have elicited enough new information to be warranted.

Crosstabs

Form * Q1: Switch lanes if possible Crosstabulation

			Q1: Switch lanes if possible		Total
			0	1	
Form	Alternating Diamonds	Count	98	40	138
		% within Q1: Switch lanes if possible	32.8%	35.4%	33.5%
	Flashing Diamonds	Count	100	37	137
		% within Q1: Switch lanes if possible	33.4%	32.7%	33.3%
	Flashing Box	Count	101	36	137
		% within Q1: Switch lanes if possible	33.8%	31.9%	33.3%
Total		Count	299	113	412
		% within Q1: Switch lanes if possible	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.271(a)	2	.873
Likelihood Ratio	.270	2	.874
Linear-by-Linear Association	.253	1	.615
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 37.58.

Crosstabs

Form * Q1: Slow down Crosstabulation

			Q1: Slow down		Total
			0	1	
Form	Alternating Diamonds	Count	75	63	138
		% within Q1: Slow down	35.7%	31.2%	33.5%
	Flashing Diamonds	Count	62	75	137
		% within Q1: Slow down	29.5%	37.1%	33.3%
	Flashing Box	Count	73	64	137
		% within Q1: Slow down	34.8%	31.7%	33.3%
Total		Count	210	202	412
		% within Q1: Slow down	100.0%	100.0%	100.0%

Figure C2 – Chi-square Tests for Survey Responses

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.714(a)	2	.257
Likelihood Ratio	2.717	2	.257
Linear-by-Linear Association	.032	1	.858
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 67.17.

Crosstabs

Form * Q1: Pay more attention Crosstabulation

			Q1: Pay more attention		Total
			0	1	
Form	Alternating Diamonds	Count	120	18	138
		% within Q1: Pay more attention	33.4%	34.0%	33.5%
	Flashing Diamonds	Count	123	14	137
		% within Q1: Pay more attention	34.3%	26.4%	33.3%
	Flashing Box	Count	116	21	137
		% within Q1: Pay more attention	32.3%	39.6%	33.3%
Total		Count	359	53	412
		% within Q1: Pay more attention	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.601(a)	2	.449
Likelihood Ratio	1.620	2	.445
Linear-by-Linear Association	.317	1	.574
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.62.

Crosstabs

Form * Q1: Continue normal driving Crosstabulation

			Q1: Continue normal driving		Total
			0	1	
Form	Alternating Diamonds	Count	128	10	138
		% within Q1: Continue normal driving	32.9%	43.5%	33.5%
	Flashing Diamonds	Count	136	1	137
		% within Q1: Continue normal driving	35.0%	4.3%	33.3%
	Flashing Box	Count	125	12	137
		% within Q1: Continue normal driving	32.1%	52.2%	33.3%
Total		Count	389	23	412
		% within Q1: Continue normal driving	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.468(a)	2	.009
Likelihood Ratio	12.484	2	.002
Linear-by-Linear Association	.291	1	.590
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.65.

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Crosstabs

Form * Q1: Look for highway work Crosstabulation

			Q1: Look for highway work		Total
			0	1	
Form	Alternating Diamonds	Count	131	7	138
		% within Q1: Look for highway work	33.5%	33.3%	33.5%
	Flashing Diamonds	Count	127	10	137
		% within Q1: Look for highway work	32.5%	47.6%	33.3%
	Flashing Box	Count	133	4	137
		% within Q1: Look for highway work	34.0%	19.0%	33.3%
Total		Count	391	21	412
		% within Q1: Look for highway work	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.716(a)	2	.257
Likelihood Ratio	2.795	2	.247
Linear-by-Linear Association	.652	1	.419
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.98.

Crosstabs

Form * Q2: Shoulder work ahead Crosstabulation

			Q2: Shoulder work ahead		Total
			0	1	
Form	Alternating Diamonds	Count	114	24	138
		% within Q2: Shoulder work ahead	31.8%	45.3%	33.5%
	Flashing Diamonds	Count	124	13	137
		% within Q2: Shoulder work ahead	34.5%	24.5%	33.3%
	Flashing Box	Count	121	16	137
		% within Q2: Shoulder work ahead	33.7%	30.2%	33.3%
Total		Count	359	53	412
		% within Q2: Shoulder work ahead	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.087(a)	2	.130
Likelihood Ratio	3.998	2	.135
Linear-by-Linear Association	2.005	1	.157
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.62.

Crosstabs

Form * Q2: Use caution ahead Crosstabulation

			Q2: Use caution ahead		Total
			0	1	
Form	Alternating Diamonds	Count	56	82	138
		% within Q2: Use caution ahead	34.6%	32.8%	33.5%
	Flashing Diamonds	Count	45	92	137
		% within Q2: Use caution ahead	27.8%	36.8%	33.3%
	Flashing Box	Count	61	76	137
		% within Q2: Use caution ahead	37.7%	30.4%	33.3%
Total		Count	162	250	412
		% within Q2: Use caution ahead	100.0%	100.0%	100.0%

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.054(a)	2	.132
Likelihood Ratio	4.088	2	.129
Linear-by-Linear Association	.442	1	.506
N of Valid Cases	412		
a 0 cells (.0%) have expected count less than 5. The minimum expected count is 53.87.			

Crosstabs

Form * Q2: Proceed normally Crosstabulation

			Q2: Proceed normally		Total
			0	1	
Form	Alternating Diamonds	Count	137	1	138
		% within Q2: Proceed normally	33.6%	25.0%	33.5%
	Flashing Diamonds	Count	137		137
		% within Q2: Proceed normally	33.6%		33.3%
	Flashing Box	Count	134	3	137
		% within Q2: Proceed normally	32.8%	75.0%	33.3%
Total		Count	408	4	412
		% within Q2: Proceed normally	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.547(a)	2	.170
Likelihood Ratio	4.330	2	.115
Linear-by-Linear Association	1.524	1	.217
N of Valid Cases	412		
a 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.33.			

Crosstabs

Form * Q2: Lane closure ahead Crosstabulation

			Q2: Lane closure ahead		Total
			0	1	
Form	Alternating Diamonds	Count	127	11	138
		% within Q2: Lane closure ahead	33.0%	40.7%	33.5%
	Flashing Diamonds	Count	127	10	137
		% within Q2: Lane closure ahead	33.0%	37.0%	33.3%
	Flashing Box	Count	131	6	137
		% within Q2: Lane closure ahead	34.0%	22.2%	33.3%
Total		Count	385	27	412
		% within Q2: Lane closure ahead	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.634(a)	2	.442
Likelihood Ratio	1.734	2	.420
Linear-by-Linear Association	1.442	1	.230
N of Valid Cases	412		
a 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.98.			

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Crosstabs

Form * Q2: Do not know Crosstabulation

			Q2: Do not know		Total
			0	1	
Form	Alternating Diamonds	Count	118	20	138
		% within Q2: Do not know	35.3%	25.6%	33.5%
	Flashing Diamonds	Count	115	22	137
		% within Q2: Do not know	34.4%	28.2%	33.3%
	Flashing Box	Count	101	36	137
		% within Q2: Do not know	30.2%	46.2%	33.3%
Total		Count	334	78	412
		% within Q2: Do not know	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.325(a)	2	.026
Likelihood Ratio	7.082	2	.029
Linear-by-Linear Association	6.195	1	.013
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 25.94.

Crosstabs

Form * Q3: Which display best prompts safe driving? Crosstabulation

			Q3: Which display best prompts safe driving?			Total
			Flashing Box	Alternating Diamonds	Flashing Diamonds	
Form	Alternating Diamonds	Count	3	79	56	138
		% within Q3: Which display best prompts safe driving?	21.4%	35.6%	31.8%	33.5%
	Flashing Diamonds	Count	4	68	65	137
		% within Q3: Which display best prompts safe driving?	28.6%	30.6%	36.9%	33.3%
	Flashing Box	Count	7	75	55	137
		% within Q3: Which display best prompts safe driving?	50.0%	33.8%	31.3%	33.3%
Total		Count	14	222	176	412
		% within Q3: Which display best prompts safe driving?	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.726(a)	4	.444
Likelihood Ratio	3.649	4	.456
Linear-by-Linear Association	.251	1	.616
N of Valid Cases	412		

a 3 cells (33.3%) have expected count less than 5. The minimum expected count is 4.66.

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Crosstabs

Q5: Gender * Q3: Which display best prompts safe driving? Crosstabulation

			Q3: Which display best prompts safe driving?			Total
			Flashing Box	Alternating Diamonds	Flashing Diamonds	
Q5: Gender	Female	Count	3	82	70	155
		% within Q3: Which display best prompts safe driving?	21.4%	36.9%	39.8%	37.6%
	Male	Count	11	140	106	257
		% within Q3: Which display best prompts safe driving?	78.6%	63.1%	60.2%	62.4%
Total		Count	14	222	176	412
		% within Q3: Which display best prompts safe driving?	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.956(a)	2	.376
Likelihood Ratio	2.089	2	.352
Linear-by-Linear Association	1.233	1	.267
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.27.

Crosstabs

Q7: Time per day * Q3: Which display best prompts safe driving? Crosstabulation

			Q3: Which display best prompts safe driving?			Total
			Flashing Box	Alternating Diamonds	Flashing Diamonds	
Q7: Time per day	Bottom half (drive least)	Count	8	117	96	221
		% within Q3: Which display best prompts safe driving?	57.1%	52.7%	54.5%	53.6%
	Top half (drive most)	Count	6	105	80	191
		% within Q3: Which display best prompts safe driving?	42.9%	47.3%	45.5%	46.4%
Total		Count	14	222	176	412
		% within Q3: Which display best prompts safe driving?	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.206(a)	2	.902
Likelihood Ratio	.206	2	.902
Linear-by-Linear Association	.039	1	.844
N of Valid Cases	412		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.49.

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Crosstabs

Q8: State * Q3: Which display best prompts safe driving? Crosstabulation

			Q3: Which display best prompts safe driving?			Total
			Flashing Box	Alternating Diamonds	Flashing Diamonds	
Q8: State	Not Utah	Count	5	63	49	117
		% within Q3: Which display best prompts safe driving?	35.7%	28.4%	27.8%	28.4%
	Utah	Count	9	159	127	295
		% within Q3: Which display best prompts safe driving?	64.3%	71.6%	72.2%	71.6%
Total		Count	14	222	176	412
		% within Q3: Which display best prompts safe driving?	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.395(a)	2	.821
Likelihood Ratio	.379	2	.827
Linear-by-Linear Association	.156	1	.693
N of Valid Cases	412		

a 1 cells (16.7%) have expected count less than 5. The minimum expected count is 3.98.

Figure C2 – Chi-square Tests for Survey Responses (Continued)

Brake Light and Lane Change Data Analysis

During the speed data collection, video was taken and counts were compiled of the following:

- Lane changes, left to right (LtoR)
- Lane changes, right to left (RtoL)
- Instances of brakelights (NBrake)

Using a subset of the predictors from the speed data, a formal ANOVA was run to test for significant effects. This test was performed only on the rural data, where more information was collected. Nothing was significantly correlated with increased braking activity (see Table C8), including sign type.

A MANOVA model was run on the more sparse urban data to see if sign type alone was related to brake light occurrences or lane changes. This test used a weighted least-squares model with traffic volume as the weight variable. There was no significant sign type effect (see Table C9).

Table C8 - ANOVA test for number of brakelights

Tests of Between-Subjects Effects

Dependent Variable: NBRAKE

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2158.175[a]	7	308.311	.346	.926
Intercept	18705.625	1	18705.625	21.005	.000
TIME	119.025	1	119.025	.134	.717
TYPE	99.225	1	99.225	.111	.741
ORDER	55.225	1	55.225	.062	.805
TIME * TYPE	50.625	1	50.625	.057	.813
TIME * ORDER	497.025	1	497.025	.558	.460
TYPE * ORDER	1092.025	1	1092.025	1.226	.276
TIME * TYPE * ORDER	245.025	1	245.025	.275	.604
Error	28497.200	32	890.537		
Total	49361.000	40			
Corrected Total	30655.375	39			

a. R Squared = .070 (Adjusted R Squared = -.133)

Table C9 - MANOVA output for testing sign type effect on number of brakelights and lane changes

Tests of Between-Subjects Effects[d]

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	LTOR	892775.551[a]	1	892775.551	.124	.742
	RTOL	798.654[b]	1	798.654	.000	.986
	NBRAKE	630968.224[c]	1	630968.224	1.131	.348
Intercept	LTOR	107442758	1	107442757.9	14.953	.018
	RTOL	407859774	1	407859773.7	188.882	.000
	NBRAKE	3074819.696	1	3074819.696	5.510	.079
TYPE	LTOR	892775.551	1	892775.551	.124	.742
	RTOL	798.654	1	798.654	.000	.986
	NBRAKE	630968.224	1	630968.224	1.131	.348
Error	LTOR	28740707.4	4	7185176.841		
	RTOL	8637355.622	4	2159338.906		
	NBRAKE	2232347.159	4	558086.790		
Total	LTOR	136973737	6			
	RTOL	416503637	6			
	NBRAKE	5953269.000	6			
Corrected Total	LTOR	29633482.9	5			
	RTOL	8638154.276	5			
	NBRAKE	2863315.383	5			

a. R Squared = .030 (Adjusted R Squared = -.212)

b. R Squared = .000 (Adjusted R Squared = -.250)

c. R Squared = .220 (Adjusted R Squared = .025)

d. Weighted Least Squares Regression - Weighted by VOLUME